JANUARY 1950

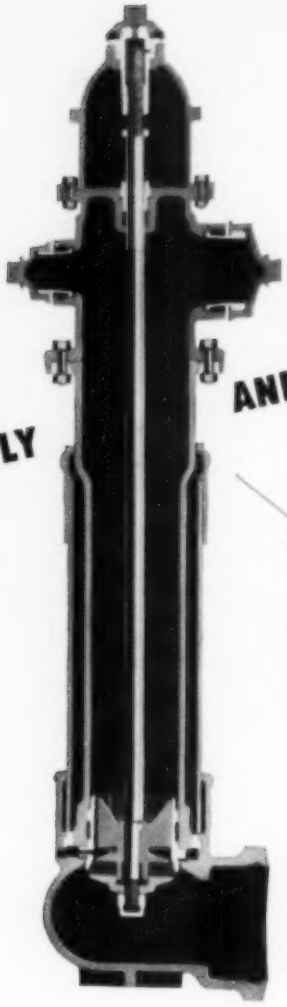
Journal

VOL. 42 • NO. 1

AMERICAN WATER WORKS ASSOCIATION

In this issue

Machine Billing	Weir
Making Annual Reports Interesting	Mayer
Pump Lubricants and Well Water Quality	Ordelheide
Synthetic-Detergent Pollution	Cross, Gallaher, Filicky, Hassler
State Highway Construction Policies	Grayson, Banks, King
Chemical and Colorimetric Methods	Connors, Diehl, Goetz, Nach, Betz, Noll
New Bacteriological Techniques	Neumann
Electron Microscope in Treatment Control	Baylis
Cation Exchangers	Lindsay, Streicher, Bowers
Water Works Standards	Jordan
Relations With State Health Departments	Hepler, Beck



SIMPLY AND SOUNDLY CONSTRUCTED

Simplicity of construction pays off in dependability and ease of maintenance.

Mathews Modernized Hydrants Set the Pace: All working parts contained in replaceable barrel • Stuffing box cast integral with nozzle section • Head can be turned 360° • Replaceable head • Nozzle outlets easily changed • Nozzle levels raised or lowered without excavating • Protection case of "Sand-Spun" cast iron for extra strength, toughness, elasticity • Operating thread only part to be lubricated • A modern barrel makes an old Mathews good as new

MATHEWS HYDRANTS

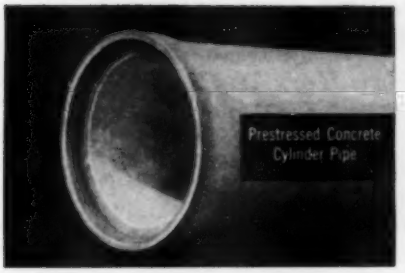
THE FIREMAN'S FRIEND

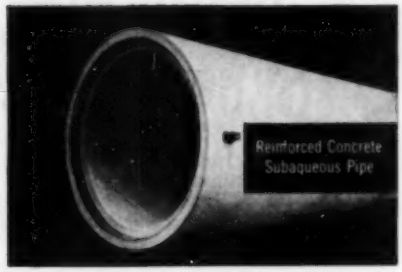
Made by R. D. Wood Company

Public Ledger Building, Independence Square

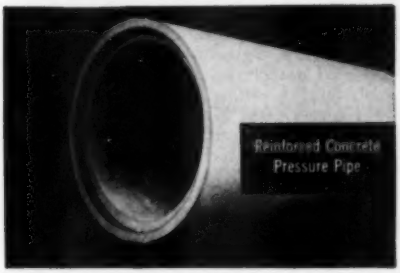
Philadelphia 5, Pa.

Manufacturers of "Sand-Spun" Pipe (centrifugally cast in sand molds) and R. D. Wood Gate Valves.





let LOCK JOINT solve your water supply problems



Lock Joint's four designs of reinforced concrete pressure pipe answer any problem in the field of large-diameter water supply conduits.

All of these designs may be equipped with Lock Joint's flexible, self-centering Rubber and Steel Joint, which simplifies installation and reduces the initial cost of laying the line.

Lock Joint Reinforced Concrete Pressure Pipe is made in all standard diameters from 16" up, and will withstand any pressure common to American water works practice.

★ ★ ★

Your inquiry at any of the Company's offices will receive a prompt reply.

LOCK JOINT PIPE COMPANY

Est. 1905

P.O. Box 269, East Orange, N. J.

PRESSURE PIPE PLANTS: Wharton, N. J., Turner, Kans., Detroit, Mich.

BRANCH OFFICES:

Cheyenne, Wyo. • Denver, Colo. • Kansas City, Mo. • Valley Park, Mo. • Chicago, Ill. • Rock Island, Ill. • Wichita, Kan. Kenilworth, N. J. • Hartford, Conn.

LOCK JOINT
Reinforced Concrete
PRESSURE PIPE

SCOPE OF SERVICES—Lock Joint Pipe Company specializes in the manufacture and installation of Reinforced Concrete Pressure Pipe for Water Supply and Distribution Mains in a wide range of diameters as well as Concrete Pipe of all types for Sanitary Sewers, Storm Drains, Culverts and Subaqueous Lines.

AMERICAN WATER WORKS ASSOCIATION
INCORPORATED

500 Fifth Avenue, New York 18, N.Y.
(Telephone: LAckawanna 4-2290)

A. P. BLACK, Head, Dept. of Chemistry, Univ. of Florida, Gainesville, Fla.	*President*
W. VICTOR WEIR	*Vice-President*
WILLIAM W. BRUSH	*Treasurer*
HARRY E. JORDAN (*Residence phone:* POrt Washington 7-2441)	*Secretary*
ERIC F. JOHNSON	*Asst. Secretary*

Board of Directors

Alabama-Mississippi Sec.	A. CLINTON DECKER, Birmingham, Ala.	to 1950
Arizona Section	ALDEN W. MILLER, Phoenix, Ariz.	–1950
California Section	CARL M. HOSKINSON, Sacramento, Calif.	–1951
Canadian Section	W. E. MACDONALD, Ottawa, Ont.	–1952
Chesapeake Section		–1951
Cuban Section	LEANDRO DE GOICOECHEA, Havana, Cuba	–1951
Florida Section	DAVID B. LEE, Jacksonville, Fla.	–1951
Illinois Section	CLIFFORD FORE, Robinson, Ill.	–1951
Indiana Section	EDWARD F. KINNEY, Indianapolis, Ind.	–1952
Iowa Section	H. F. BLOMQUIST, Cedar Rapids, Iowa	–1952
Kansas Section	MAJOR C. HAGAR, Lawrence, Kan.	–1952
Kentucky-Tennessee Sec.	C. M. MCCORD, Memphis, Tenn.	–1950
Michigan Section	RENE J. LA MARRE, Dearborn, Mich.	–1950
Minnesota Section	D. B. MORRIS, St. Paul, Minn.	–1951
Missouri Section	M. P. HATCHER, Kansas City, Mo.	–1952
Montana Section	JOHN W. HALL, Fort Shaw, Mont.	–1951
Nebraska Section	JOHN C. DETWEILER, Omaha, Neb.	–1950
New England Section	P. A. SHAW, Manchester, N.H.	–1950
New Jersey Section	CHARLES H. CAPEN, Wanaque, N.J.	–1950
New York Section	WALLACE T. MILLER, Ossining, N.Y.	–1950
North Carolina Section	GEORGE S. MOORE, Albemarle, N.C.	–1952
Ohio Section	L. T. FAWCETT, Youngstown, Ohio	–1951
Pacific Northwest Sec.	WALTER J. MOORE, Eugene, Ore.	–1950
Pennsylvania Section	MYRON G. MANSFIELD, Pittsburgh, Pa	–1950
Rocky Mountain Section	DANA E. KEPNER, Denver, Colo.	–1952
Southeastern Section		
Southwest Section	M. B. CUNNINGHAM, Oklahoma City, Okla.	–1951
Virginia Section	H. E. LORDLEY, Richmond, Va.	–1952
West Virginia Section	T. J. BLAIR JR., Charleston, W.Va.	–1952
Wisconsin Section	WILLIAM U. GALLAHER, Appleton, Wis.	–1952
Manufacturer	DANIEL J. SAUNDERS, New York, N.Y.	–1952
Manufacturer	WILLARD F. ROCKWELL, Pittsburgh, Pa.	–1950
Manufacturer	WILLIAM J. ORCHARD, Newark, N.J.	–1951

Ex-Officio Members of the Board

President	A. P. BLACK, Gainesville, Fla.	–1951
Past-President	LINN H. ENSLOW, New York, N.Y.	–1950
Vice-President	W. VICTOR WEIR, University City, Mo.	–1950
Treasurer	WILLIAM W. BRUSH, New York, N.Y.	–1950
Ch. W. W. Practice Com.	LOUIS R. HOWSON, Chicago, Ill.	–1950
Ch. W. W. Admin. Com.	WENDELL R. LADUE, Akron, Ohio	–1950
Ch. Publication Com.	CHARLES H. CAPEN, Wanaque, N.J.	–1950

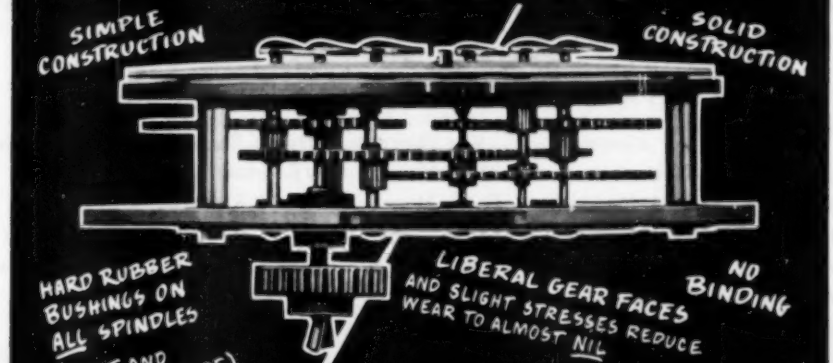
Journal A.W.W.A. is published monthly at Prince & Lemon Sts., Lancaster, Pa., by the Am. Water Works Assn., Inc., 500 Fifth Ave., New York 18, N. Y., and entered as second class matter Jan. 23, 1943, at the Post Office at Lancaster, Pa., under the Act of Aug. 24, 1912. Accepted for mailing at a special rate of postage provided for in Sec. 1103, Act of Oct. 3, 1917; authorized Aug. 6, 1918.

Copyright, 1950, by the American Water Works Association, Inc.

Made in United States of America

Why TRIDENT Meters LAST LONGER and KEEP THEIR ACCURACY!

① THE REGISTER


SIMPLE CONSTRUCTION
SOLID CONSTRUCTION
HARD RUBBER BUSHINGS ON ALL SPINDLES (HEAT AND CORROSION PROOF)
LIBERAL GEAR FACES AND SLIGHT STRESSES REDUCE WEAR TO ALMOST NIL
NO BINDING
NO BOLTS – NO SCREWS
50 YEARS OF INTERCHANGEABILITY

THE simplicity and the solid construction of the Trident Register is typical of the entire Trident Meter. Made of the finest materials; gauged, checked and rechecked for absolute accuracy at every point in their production, these rugged precision instruments retain their high accuracy during many years of operation.

You can't beat Trident Meters for maximum revenue and minimum maintenance costs.

212

New improved parts in old Trident Meter

NEPTUNE METER COMPANY • 50 West 50th Street • NEW YORK 20, N. Y.
Branch Offices in Chicago, San Francisco, Los Angeles, Portland, Ore., Denver, Dallas, Kansas City, Louisville, Atlanta, Boston.
NEPTUNE METERS, LTD., Long Branch, Ont., Canada

DIVISION AND SECTION OFFICERS

Officers of the Divisions

Water Purification Division—Chairman, J. E. KERSLAKE; Vice-Chairman, H. E. LORDLEY; Secretary-Treasurer, R. L. DERBY; Directors, M. E. FLENTJE, H. O. HARTUNG, I. M. GLACE.

Water Resources Division—Chairman, L. W. GRAYSON; Vice-Chairman, H. E. HUDSON, JR.; Secretary-Treasurer, G. E. FERGUSON; Directors, RICHARD HAZEN, D. D. GROSS.

Water Works Management Division—Chairman, G. E. ARNOLD; Vice-Chairman, L. J. HOFFMAN; Secretary-Treasurer, PAUL WEIR; Directors, J. L. HAWKINS, M. B. CUNNINGHAM.

Officers of the Sections

*Section**	*Chairman*	*Vice-Chairman*	*Secretary-Treasurer*	*Past-Chairman*
Alabama-Miss.	G. H. Godwin	T. H. Allen	J. L. Snow	B. F. Wade
Arizona	A. A. Frederickson	G. W. Marx	Mrs. H. Rotthaus	J. F. Rauscher
California	E. A. Reinke	G. E. Arnold	W. W. Aultman	L. W. Grayson
Canadian	N. MacNicol		A. E. Berry	R. H. Martindale
Chesapeake	C. Gardner	D. Auld	C. J. Lauter	E. A. Schmitt
Cuban	M. J. Puente	L. Radelat	L. H. Daniel	L. A. Nunez
Florida	S. K. Keller	S. W. Wells	A. E. Williamson	W. W. Gillespie
Illinois	H. R. Frye	J. C. Moomau	C. N. Brown	S. T. Anderson
Indiana	M. P. Crabill	J. Gordon	C. H. Bechert	C. E. Williams
Iowa	G. Nelson	M. E. Driftmier	H. V. Pedersen	R. O. Ellis
Kansas	A. B. Mawdsley	A. W. Rumsey	H. W. Badley	H. H. Kansteiner
Kentucky-Tenn.	R. W. Williamson	J. W. McCoy	R. P. Farrell	Miss L. Suther'and
Michigan	J. E. Cooper	G. Hazey	T. L. Vander Velde	J. F. Dye
Minnesota	A. F. Mellen	H. Lundquist	R. M. Finch	H. G. Tischer
Missouri	R. E. Piner	C. E. Schanze	W. A. Kramer	J. F. Sanders
Montana	M. F. Dixon	M. E. Henderson	C. W. Brinck	J. B. Hazen
Nebraska	V. Livingston	C. W. Burdick	J. W. Cramer	G. E. Bell
New England	W. A. Gentner	D. C. Calderwood	R. H. Ellis	W. B. Duffy
New Jersey	R. E. Bonyun	A. Shinn	C. B. Tygert	P. S. Wilson
New York	L. B. Smith	A. T. Luce	R. K. Blanchard	J. M. Wardle
North Carolina	R. W. Luther	E. R. Tull	E. C. Hubbard	W. M. Franklin
Ohio	A. A. Ullrich	A. S. Hibbs	F. P. Fischer	T. R. Lathrop
Pacific Northwest	B. C. Gosney	E. James	O. P. Newman	J. E. Morrison
Pennsylvania	E. C. Goehring	T. H. Kain	L. S. Morgan	E. J. Taylor
Rocky Mountain	B. V. Howe	C. G. Caldwell	G. J. Turre	H. M. Krull
Southeastern	T. A. Jones	J. F. Pearson	T. A. Kolb	W. R. Wise
Southwest	J. R. Pierce	K. F. Hoefle	L. A. Jackson	D. W. Robinson
Virginia	E. C. Meredith	R. D. Wright	W. H. Shewbridge	H. E. Silcox
West Virginia	M. K. Jones	W. S. Staub	J. B. Harrington	J. A. Sample
Wisconsin	T. M. McGuire	F. K. Quimby	L. A. Smith	J. A. Snow

* For Section's representative on the A.W.W.A. Board of Directors, see list on page ii.

Who benefits from Quality Control?

What is Quality Control? What does it do? How does it function? Whom does it benefit?

First and foremost, a quality control operation benefits the customer. It also benefits the manufacturer. It provides assurance to management that the quality level of production is equal to, and generally in excess of, the standard specification.

Take us, for example. We manufacture cast iron pressure pipe in accordance with quality control specifications that are more comprehensive and exacting than the accepted technical specifications or customer's specifications under which pipe is purchased.

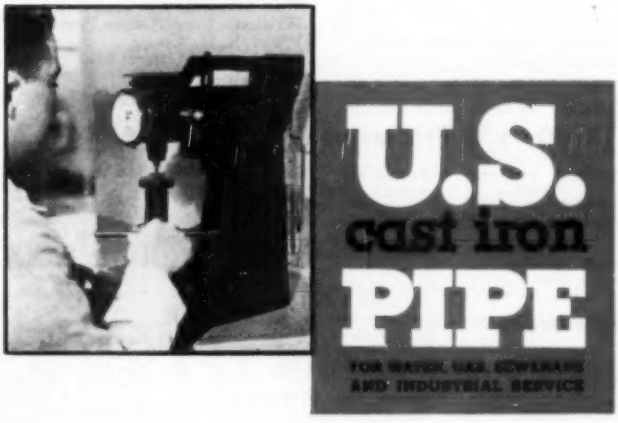
The first step in Quality Control is that of establishing company standards for both process methods and the physical and chemical properties of the product.

The next, backing-up step is establishing inspection procedures using statistical sampling techniques. These procedures extend from raw materials to finished product.

The final step is to have our Quality Control Dept. establish a group of facts in statistical form and analyze them for the purpose of removing quality standards from the realm of *opinion* into that of *organized facts*.

Production testing laboratories in our various plants are the tools for evaluating these quality standards.

U.S. Pipe & Foundry Co., General Offices, Burlington, N. J., *America's largest producer of cast iron pressure pipe.*

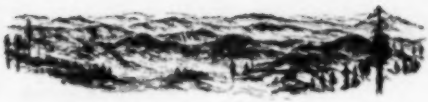


LIST OF ADVERTISERS

Aluminum Co. of America, Chemicals Div. 5
American Brass Co., The ..... Cover 3
American Cast Iron Pipe Co. ..... —
American Cyanamid Co., Industrial Chemicals Div. 18
American Norit Co., Inc. ..... —
American Pipe & Construction Co. 43
American Well Works ..... —
Anthracite Equipment Corp. ..... —
Armco Drainage & Metal Products, Inc. 33
Art Concrete Works ..... —
Atlas Mineral Products Co., The 16
Badger Meter Mfg. Co. ..... —
Barrett Div., The ..... —
Belco Industrial Equipment Div., Inc. ..... —
Bethlehem Steel Co. ..... —
Buffalo Meter Co. ..... —
Builders-Providence, Inc. 69
Calgon, Inc. 9
Carson-Cadillac Co. ..... —
Cast Iron Pipe Research Assn., The 46–47
Central Foundry Co., The 54
Centriline Corp. 21
Chain Belt Co. ..... —
Chicago Bridge & Iron Co. 49
Clow, James B., & Sons 39
De Laval Steam Turbine Co. 51
Dorr Co., The ..... —
Dowell Incorporated ix
Dresser Mfg. Div. 57
Economy Pumps, Inc. 3
Eddy Valve Co. 39
Electric Fish Screen Co. ..... —
Electro Rust-Proofing Corp. 6
Ellis & Ford Mfg. Co. 59
Everson Mfg. Corp. 59
Fairbanks, Morse & Co. ..... —
Flexible Sewer-Rod Equipment Co. 58
Ford Meter Box Co., The 67
General Chemical Div., Allied Chemical & Dye Corp. 65
Greenberg's, M., Sons 42
Graver Water Conditioning Co. ..... —
Hamilton-Thomas Corp. 3
Harco Corp., Rusta Restor Div. ..... —
Hayman, Michael, & Co., Inc. ..... —
Hays Mfg. Co. 7
Hellige, Inc. 40
Hersey Mfg. Co. 19
Hungerford & Terry, Inc. 36
Hydraulic Development Corp. 53
Industrial Chemical Sales Division, West Virginia Pulp & Paper Co. x
Inertol Co., Inc. ..... —
Infilco, Inc. 61
Iowa Valve Co. 39
Johns-Manville Corp. ..... —
James Jones Co. 63
Keasbey & Mattison Co. vii
Kennedy Valve Mfg. Co., The ..... —
Klett Mfg. Co. 22
Koppers Co., Inc. 29
Kupferle, John C., Foundry Co. 16
LaMotte Chemical Products Co. ..... —
Layne & Bowler, Inc. 13
Leadite Co., The ..... Cover 4
Lock Joint Pipe Co. i
Ludlow Valve Mfg. Co. ..... —
M & H Valve & Fittings Co. 71
Mueller Co. ..... —
National Cast Iron Pipe 39
National Water Main Cleaning Co. 37
Neptune Meter Co. iii
Northern Gravel Co. 38
Northrop & Co., Inc. 10
Omega Machine Co. (Div., Builders Iron Fdry.) 45
Peerless Pump Div. ..... —
Permutit Co. 17
Phelps Dodge Refining Corp. ..... —
Philadelphia Gear Works, Inc. 60
Photovolt Corp. ..... —
Pittsburgh-Des Moines Steel Co. ..... —
Pittsburgh Equitable Meter Div. (Rockwell Mfg. Co.) 74
Pollard, Jos. G., Co., Inc. 14
Portland Cement Assn. ..... —
Proportioneers, Inc. 55
Reilly Tar & Chemical Co. ..... —
Rensselaer Valve Co. 11
Roberts Filter Mfg. Co. ..... —
Ross Valve Mfg. Co. 31
Simplex Valve & Meter Co. 35
Smith, A. P., Mfg. Co., The 23
Solvay Sales Div., Allied Chemical & Dye Corp. ..... —
Sparling, R. W. 54
Stuart Corp. 52
U. S. Pipe & Foundry Co. v
Virginia Smelting Co. 34
Walker Process Equipment, Inc. ..... —
Wallace & Tiernan Co., Inc. xii
Warren Foundry & Pipe Corp. 73
Well Machinery & Supply Co. 15
Welsbach Corp., Ozone Processes Div. ..... —
Wood, R. D., Co. ..... Cover 2
Worthington-Gamon Meter Co. 41

Directory of Professional Services—pp. 24-27

Albright & Friel, Inc.
Alvord, Burdick & Howson
Bays, Carl A. & Assoc.
Behrman, A. S.
Black Labs., Inc
Black & Veatch
Clinton L. Bogert Assoc.
Bowe, Albertson & Assoc.
Buck, Seifert and Jost
Burgess & Niple
Burns & McDonnell Eng. Co.
Caird, James M.
Camp, Dresser & McKee
Chester, Engineers, The
Consoer, Townsend & Assoc.
De Leuw, Cather & Co.
Fay, Spofford & Thorndike
Fent, O. S.
Gannett Fleming Corddry & Carpenter, Inc.
Gilbert Assoc., Inc.
Glace, Ivan M.
Greeley & Hansen
Havens & Emerson
Haydock, Charles
Hitchcock & Estabrook, Inc.
Horner & Shifrin
Hunt, Robert W., Co.
Jones, Henry & Schoonmaker
Knowles, Morris, Inc.
Leggette, R. M.
Roberto Meneses Hoyos & Co.
Metcalf & Eddy
Nutting, H. C., Co.
Parsons, Brinckerhoff, Hall & Macdonald
Malcolm Pirnie Engineers
Pitometer Co.
Purcell, Lee T.
Riddick, Thomas M.
Ripple & Howe
Rose, Nicholas A.
Russell & Axon
Sirrine, J. E., Co.
Stanley Eng. Co.
Stilson, Alden E. & Assoc.
Ward & Strand
Weston & Sampson
Whitman & Howard
Whitman, Requardt & Assoc.



"QUICK EXECUTION OF THE JOB WAS ESSENTIAL"

K&M "CENTURY" ASBESTOS-CEMENT PIPE

DID IT GOOD 'N' FAST!

Gatlinburg, Tennessee, is the "Gateway to the Great Smoky Mountains." Much local and regional trade depends on tourist traffic. The use of K&M "Century" Asbestos-Cement Pipe for the new water mains resulted in a minimum of obstruction to travel and business during installation.

Here is the good report: The pipe's light weight "eliminated use of heavy laying equipment" (saving cost, needless tie-ups and business slowdown). "Ease with which the pipe was tightly joined with 'Century' Simplex Couplings permitted backfilling the trenches immediately and greatly contributed to fast installation."

So the whole region gained, and now the taxpayers will be spared the inconvenience and maintenance expense resulting from corrosion, tuberculation and electrolysis. Inherently free of those old drawbacks, K&M "Century" Pipe keeps flow area, friction factor, and pumping cost at their initial figure! More than a match for the stresses of earth settlement and traffic vibration, this modern K&M type of main actually strengthens with age. Wherever used it makes the job go faster—better—and pays the public. Write us for data.

Nature made Asbestos...

Keasbey & Mattison has made it serve mankind since 1873

KEASBEY & MATTISON

COMPANY • AMBLER • PENNSYLVANIA

COMING MEETINGS

A.W.W.A. 1950 ANNUAL CONFERENCE

Philadelphia, Pa.

May 21–26

Reservation forms have been mailed to all members, and all reservations will be cleared through the A.W.W.A. office. The hotels have agreed to accept no reservations for the 1950 Conference except as they are requested on the standard form prepared by the A.W.W.A.

Accommodations at Eleven Hotels

All Technical Sessions and Exhibits at Convention Hall

February 15—New Jersey Section Luncheon at Essex House, Newark. Secretary: C. B. Tygert, Box 178, Newark 1, N.J.

March 16—New England Section business meeting. Secretary: R. H. Ellis, Engr., Factory Mutual Eng. Div., 184 High St., Boston 10, Mass.

30–31—New York Section at Hotel Sheraton, Rochester. Secretary: R. K. Blanchard, Vice Pres., Neptune Meter Co., 50 W. 50th St., New York, N.Y.

31–Apr. 2—Arizona Section at Safford. Secretary: Mrs. Helen Rotthaus, San. Eng. Div., State Dept. of Health, Phoenix, Ariz.

April 3–5—Canadian Section at General Brock Hotel, Niagara Falls. Secretary: A. E. Berry, Dir., Ontario Dept. of Health, Parliament Bldgs., Toronto 2, Ont.

12–14—Illinois Section at LaSalle Hotel, Chicago. Secretary: Carl N. Brown, Western Sales Mgr., U.S. Pipe & Foundry Co., 122 S. Michigan Ave., Chicago 3, Ill.

20–21—Kansas Section. Secretary: H. W. Badley, Repr., Neptune Meter Co., 640 Highland St., Salina, Kan.

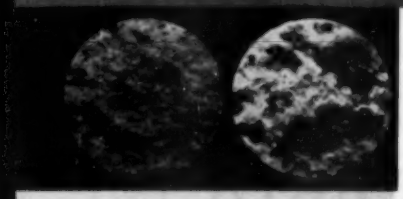
21–22—Montana Section at Florence Hotel, Missoula. Secretary: C. W. Brinck, Montana State Board of Health, Helena, Mont.

26–28—Indiana Section at Purdue Univ., Lafayette. Secretary: C. H. Bechert, Dir., Div. of Water Resources, Ind. Dept. of Conservation, 445 N. Pennsylvania, Rm. 200, Indianapolis 4, Ind.

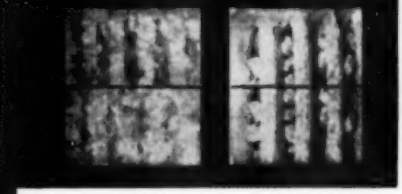
May 11–13—Pacific Northwest Section at Tacoma, Wash. Secretary: Oscar P. Newman, Boise Water Corp., Boise, Idaho.

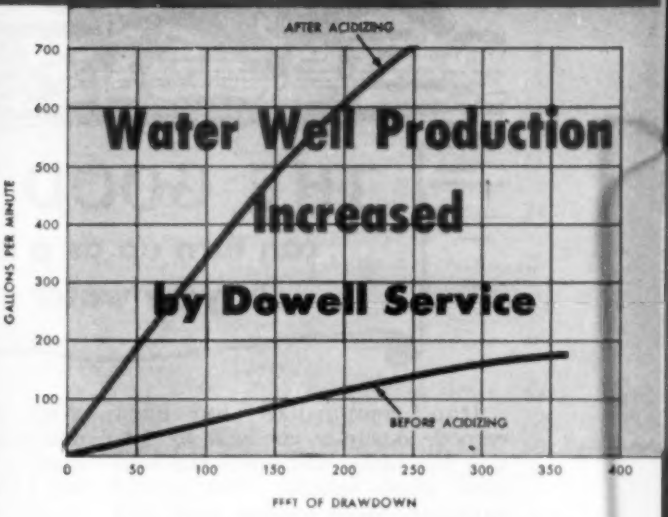
DOWELL

SPECIALISTS IN SCALE AND SLUDGE REMOVAL WITH CHEMICALS



Acidizing of the limestone core above produced the enlarged passages shown in the right hand photograph. The photographs below, taken with a subsurface camera, show the screen in a gravel-packed well before and after acidizing.





Drawdown Curves showing the advantages which have been obtained from proper chemical treating of water wells.

Scale incrustations and corrosion products on the well screen, pump, tubing and face of the producing formation will cut down the output of your water well. Dowell Acidizing Service is designed to remove these water-stealing deposits easily and quickly. Also, production may be increased due to enlargement of the water passages in the formation itself.

Case histories of many Dowell serviced wells show excellent results. For example, in a 1900 foot deep water well, calcium carbonate and iron oxide incrustations on the slotted liner had cut production to 65 g.p.m. After Dowell service, the well produced 632 g.p.m.—*an 872% increase.*

Dowell Acidizing Service requires a minimum amount of mechanical work since pulling of the pump or the screen is usually unnecessary. Experienced Dowell engineers do the entire treatment—using mobile equipment, they bring the proper solvents to the well site along with all necessary pumps, mixers and control equipment. Your nearest Dowell office will be glad to give you complete information and free cost estimates.

DOWELL INCORPORATED · TULSA 3, OKLAHOMA

SUBSIDIARY OF THE DOW CHEMICAL COMPANY

New York 20	Buffalo 2	Kansas City 8	Mt. Pleasant, Mich.
Boston 16	Cleveland 13	Wichita 2	Hamilton, Ohio
Philadelphia 2	Pittsburgh 19	Oklahoma City 2	Charleston 27, W. Va.
Baltimore 18	Detroit 2	Houston 2	Salem, Illinois
Wilmington 99	Chicago 2	New Orleans 12	Borger, Texas
Richmond 19	St. Louis 8	Ft. Worth 2	Midland, Texas
Jacksonville	Indianapolis	Shreveport 23	Wichita Falls, Tex.
Atlanta	Louisville	Anniston, Alabama	Lafayette, La.

Long Beach, Oakland, Casper: Dowell Associate-International Companies, Inc.

CALL

DOWELL

A SERVICE ORGANIZATION

THE GOOD EARTH

can turn up as a bad taste in your water supply

Don't jeopardize your hard earned consumer goodwill by letting vile tastes and odors slip into your water supply. You should anticipate these sudden taste and odor outbursts by stocking an adequate supply of Aqua Nuchar Activated Carbon. Then, by frequently conducted Threshold Odor Tests you can determine the exact quantity of Aqua Nuchar necessary to remove the objectionable taste or odor.

The Threshold Odor Test supplies a relatively simple means of measuring odor intensities in water. With this test it is possible to determine the quantity and the quality of activated carbon which will be most effective for removing unwanted tastes and odors from any individual water supply.

Water works officials are invited to write to our nearest sales office for complete information regarding the Threshold Odor Test. Water purification experts from our Technical Service Department are available to study your taste and odor problems without cost or obligation.

industrial CHEMICAL SALES

division west virginia pulp and paper company

NEW YORK CENTRAL BLDG.
230 PARK AVENUE
NEW YORK 17, N. Y.

PURE OIL BLDG.
35 E. WACKER DRIVE
CHICAGO 1, ILLINOIS

PUBLIC LEDGER BLDG.
INDEPENDENCE SQUARE
PHILADELPHIA 6, PA.

LEADER BLDG.
526 SUPERIOR AVE., N.W.
CLEVELAND 14, OHIO

Journal

AMERICAN WATER WORKS ASSOCIATION | **Vol. 42 • No. 1**

COPYRIGHT, 1950, BY THE AMERICAN WATER WORKS ASSOCIATION, INC.

January 1950

Contents

Machine Billing at Atlanta ..... PAUL WEIR 1
Making Annual Reports Interesting ..... E. B. MAYER 9
Well Pump Bearing Lubricants and Bacteriological Quality ..... L. E. ORDELHEIDE 14
Effects of Synthetic-Detergent Pollution—*Panel Discussion:*
Effect on Coagulation ..... JOHN T. CROSS 17
Appleton Experience ..... WILLIAM U. GALLAHER 22
Effect on Palatability ..... JOSEPH G. FILICKY & JOHN W. HASSLER 24
Effects of State Highway Construction Policies on Utility Installations
L. W. GRAYSON, WILLIAM G. BANKS & ARTHUR C. KING 26
Advances in Chemical and Colorimetric Methods ..... J. J. CONNORS 33
The Versenate Titration for Total Hardness
HARVEY DIEHL, CHARLES A. GOETZ & CLIFFORD C. HACH 40
Total-Hardness Determination by Direct Colorimetric Titration
J. D. BETZ & C. A. NOLL 49
Possibilities of Newer Bacteriological Techniques ..... HARRY G. NEUMANN 57
Use of Electron Microscope in Water Treatment Control ..... JOHN R. BAYLIS 66
High-Capacity Cation Exchangers ..... F. K. LINDSAY 75
Cation Exchangers for Municipal Water Softening
LEE STREICHER & A. E. BOWERS 81
The Value of Standards to the Water Works Industry ..... HARRY E. JORDAN 93
What the State Health Department Expects From Licensed Water Works Operators ..... JOHN M. HEPLER 98
The State Board of Health and Public Water Supplies ..... ARTHUR N. BECK 103

Departments

Officers & Directors ii
Division & Section Officers iv
List of Advertisers vi
Coming Meetings viii
Percolation & Runoff 1
Correspondence 22
Membership Changes 28
Service Lines 40
Section Meeting Reports 44
Index of Advertisers' Products 68

Reproduction of the contents, either as a whole or in part, is forbidden, unless specific permission has been obtained from the Editor of this JOURNAL. The Association is not responsible, as a body, for the facts and opinions advanced in any of the papers or discussions published in its proceedings.

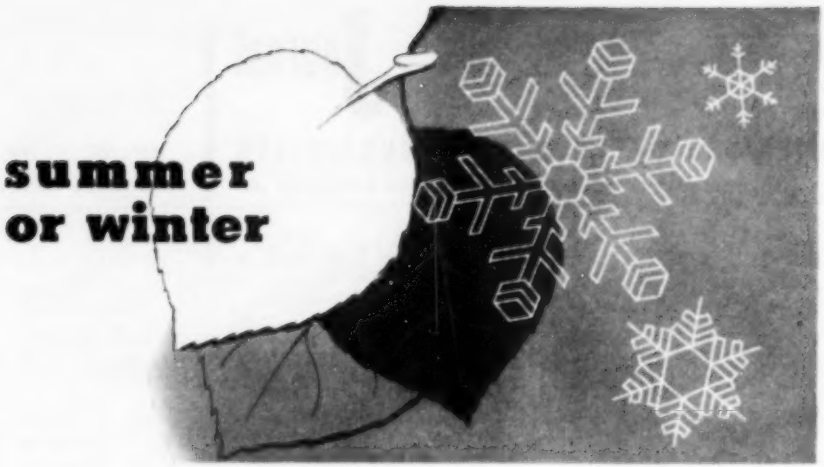
Indexed annually in December; and regularly by *Industrial Arts Index* and *Engineering Index*.
Microfilm edition (for JOURNAL subscribers only) by University Microfilms, Ann Arbor, Mich.

All correspondence relating to the publication of papers should be addressed to:

Harry E. Jordan, Secretary—500 Fifth Avenue, New York 18, N.Y.

ERIC F. JOHNSON, *Editor* — LAWRENCE FARBER, *Associate Editor*
DANIEL N. FISCHEL, *Managing Editor* — ELIZABETH M. BRADY, *Associate Editor*

$7.00 of members' dues are applied as a subscription to the JOURNAL; additional single copies to members—50 cents; single copies to non-members—75 cents.



BREAK-POINT HELPS THIS WEST COAST WATER WORKS

Typical of what Break-Point Chlorination can accomplish is this case history.

A 1½ mgd. west coast water works using an impounded supply was troubled by summertime odors so acute that settling basins had to be washed almost continuously, while in the winter, color ran as high as 600 ppm. To overcome these troubles, several treatment methods were tried—unsuccessfully. Then W&T Engineers, in cooperation with the plant staff, carefully analyzed the situation. At their suggestion, the Break-Point Process was employed, using W&T Chlorinators for pre-chlorination. With this treatment, according to a report by staff members, color troubles, together with complaints concerning iron and manganese stains, were eliminated; filter runs increased; and summertime odors cut almost to the vanishing point.

In addition to such direct chlorination benefits, when you call on W&T you have the added assurance of W&T's 35 years of chlorination experience—a full line of chlorinators from which to choose—the backing of extensive research and development facilities—and finally, a top-notch, alert field organization at your call for prompt service and technical assistance.

For more details, ask your nearest W&T Representative —he'll be glad to help you.

The W&T Residual Chlorine Recorder is especially valuable in securing the best possible results with the Break-Point Process.

WALLACE & TIERNAN
COMPANY, INC.
CHLORINE AND CHEMICAL CONTROL EQUIPMENT
S-39 NEWARK 1, NEW JERSEY • REPRESENTED IN PRINCIPAL CITIES

Journal

AMERICAN WATER WORKS ASSOCIATION

VOL. 42 • JANUARY 1950 • NO. 1

Machine Billing at Atlanta

By Paul Weir

A paper presented on June 2, 1949, at the Annual Conference, Chicago, by Paul Weir, Gen. Mgr., Water Dept., Atlanta, Ga.

POSTCARD billing inaugurates a new era in the billing and accounting procedure of the Atlanta Water Works. The new mechanized billing system, which replaced a 25-year-old plan, has been adopted in order to render more adequate service to the customer, absorb normal yearly increases in accounts and provide the department with statistical data at a substantial overall saving.

The new system resulted from a study of four different billing and accounting procedures over a period of two years. The International Business Machine method and equipment were chosen to handle Atlanta's 85,000 monthly accounts, comprising 23 zones, each with ten routes listing 300–350 customers.

The following IBM * equipment was installed: two Alphabetic Key Punches, an Interpreter, two Alphabetical Accounting Machines, a Reproducing Summary Punch, a Collator and a Sorter. In addition, a Moore † Burster and a Moore † Imprinter were installed.

Method of Conversion

A carefully prepared program, including an outline of procedure, was developed before converting the city's hand-delivered water bill system to the new postcard method. This preliminary work proved to be of inestimable value as the new program developed. It was demonstrated, however, that there is no substitute for experience. Most of the conversion problems were found to be normal for this type of change. For instance, a sampling of names and addresses in the various service zones indicated that discrepancies existed. In one instance, a man was receiving his water bill in his grandfather's name. Another bill was

* International Business Machines Corp., New York.

† Moore Business Forms, Inc., Southeastern Div., Eastern Area, Atlanta, Ga.

being forwarded to a former customer who had moved to France. A fairly simple plan was evolved to insure correct customers' names and addresses. A manually applied stamp was affixed to the old form of water bill prior to the changeover, requesting the addressee to telephone "Mr. Garner" if the name or street address of the account served was incorrect. The telephone number of the water works business office was given. Garner is the supervisor of the service department, but his name was used merely to indicate that a customer desired to correct his name or address. The telephone receptionists were instructed to channel all calls for "Mr. Garner" to him or to clerks designated to handle this phase of the work, and each clerk was supplied with a "change-of-address" pad to facilitate handling calls. Approximately 100 changes were made daily for a 60-day period. The value of this method was demonstrated when the new bills were first mailed out, less than 0.5 per cent being returned for incorrect name or address.

The last hand-delivered water bill carried a Willing Water message announcing that the customer's next bill would be mailed to him on a penny postcard.

Three former IBM key punch operators were temporarily employed to punch master name and address cards and help convert the old system to the new, thus materially expediting and facilitating the changeover. A program of personnel training was developed, in order that a majority of the employees in this department might attend classes at the local IBM school. The intensified training period developed confidence and skill in the operation of the highly mechanized equipment. The training period was in progress three months before the machines were installed, during which time detailed procedure manuals were developed for each operation and operator. A scientific motion study was made of the available space in which the machines were to be placed, and an arrangement was devised which afforded an uninterrupted flow of the work from

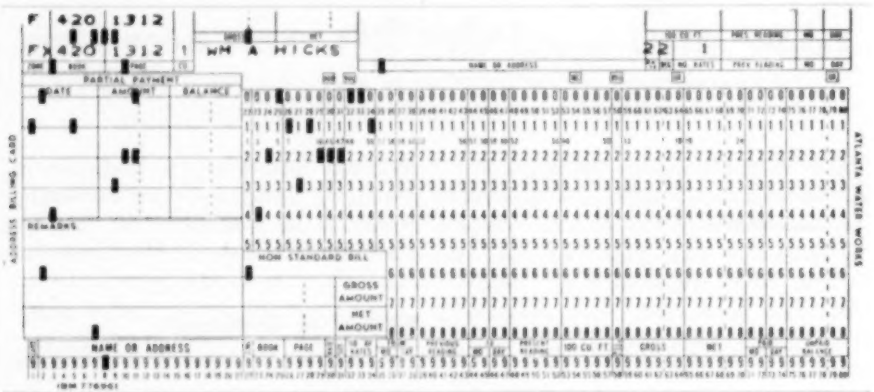


FIG. 1. Master Name Punch Card

meter book readings to the completed bill (*see* Fig. 5, p. 6).

Supervisory personnel during the inaugural period were furnished by IBM. Five months were required in the conversion process, the last two of which included the complete installation and operation of all machines.

Billing Method

In order to set up the mechanical billing system, the name and address of each account must be punched on separate master punch cards. The master name punch card (Fig. 1) contains the name of the account; the service zone number; the meter book and page number; an office code number; and data regarding the class and number of rates and the meter size, which determine the unit rates. The master address punch card contains the same items, except that the address is shown in place of the name. An Alphabetic Key Punch is used to punch this information on the cards. By means of the Interpreter, the data on each card are also automatically printed in letters at the top.

In addition, a set of master rate revenue punch cards (Fig. 2) must be prepared. Each such card contains the previously computed gross and net charges for a specific quantity of water at a particular rate. (Any or all of the items punched on a set of master cards can be reproduced automatically on another set of cards.)

Each month an advance card file is automatically created from the previous month's billing. The advance billing card contains the same information as the master address card, plus the previous meter reading. The present meter reading and the computed consumption for the month are then punched on the card.

The billing cards are next run through the Alphabetical Accounting Machine, which automatically checks and proves the accuracy of the key punch operation and the computation of monthly consumption. Afterward the cards are put through the Sorter, which arranges them according to rate

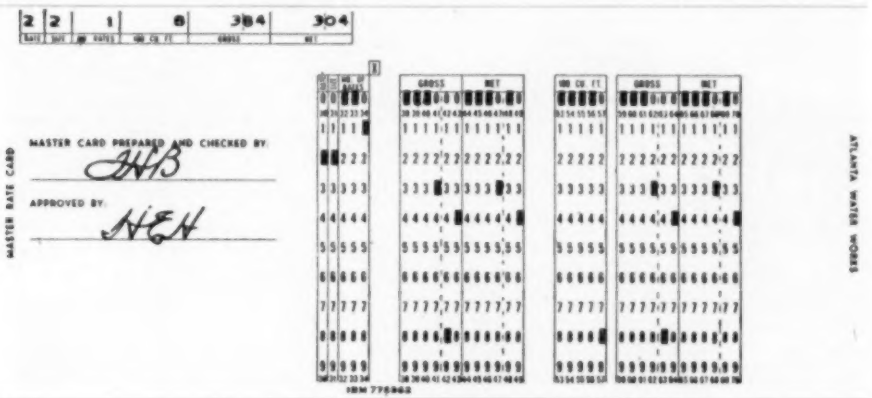


FIG. 2. Master Rate Punch Card

classification, grouping together all cards with the same consumption figure.

It is then necessary to insert in the proper place in the billing card file the master rate card applying to each consumption group. This operation, called "merging," is performed by the Collator. When the billing and rate cards have been merged, the Reproducing Summary Punch is used to duplicate, on the billing cards, the gross and net consumption charges previously punched on the master rate cards. Approximately 6,000 rate cards—divided equally between inside city and outside city rates—are used to handle 99 per cent of all the accounts. This step completes the data to be punched on the billing cards. A control list is then run on metered water, fire service, balance due and miscellaneous charges, and a "route book control sheet" (Fig. 3) is prepared.

The billing cards, re-sorted into account number sequence (zone-book-page number), are then merged by the Collator with the master name cards (similarly arranged), to ascertain that there is a billing card for each account and that both sets are in proper sequence. This operation assures that, when the postcard bills are run off, the billing side and the name and address side of each card will show information for the same account. Using the Alphabetical Accounting Machine, selected data from the cards are listed on a billing register, which provides all of the information needed for preparing duplicate bills and answering inquiries.

The two Alphabetical Accounting Machines (Fig. 4) now perform the function of printing the postcard bills. In a steady flow, the postcard stock and name and address cards pass through the machines, which print at the rate of 80 lines per minute. A similar procedure is followed in print-

ROUTE BOOK CONTROL

DAY 5-6-57

BOOK NO.	120	121	122	123	124	125	126	127	128	129	ZONE TOTAL
READ BY	Jones	Smith	Black	Henry	Doe	Brown	Roe	Jones	Reed	Hubbard	
METERS IN BOOK	300	330	310	332	341	321	319	348	320	314	3241
METERS OFF	2	6	2	8	1	1	1	6	4	2	32
METER READER ERRORS	1	3		4		1	2	1		1	13
METERS ESTIMATED	2		1	2	4	1	2	3	1		16
TOTAL CONSUMPTION	4535	5902	4218	5960	4620	4459	4324	4261	4162	4321	43,690
TOTAL REVENUE	136.26	697.80	726.42	656.27	552.60	716.24	779.36	732.47	824.35	932.50	7,704.77
FIRE SERVICE	5.00	12.00		6.00	8.00	4.00		5.00	6.00	27.00	69.00
MISC. DR. & CR.											
BAL. FWD.	6.30	27.45	14.00	52.84	1.50	2.75	52.30	21.60	14.27	32.90	183.66
BILLING CONTROL	79.56	687.25	740.42	695.16	824.10	747.99	812.66	757.07	844.62	992.40	7,957.43

FIG. 3. Route Book Control Sheet

ing the billing side of the card. During the operation, the amounts billed are accumulated for verification to the amounts previously entered on the zone route book sheet. It requires from two to four punched cards to produce each postcard water bill, depending upon the use of a service address or additional addresses.

The completed continuous-form postcards are next run through an Imprinter which affixes net and gross payable dates and the monthly Willing Water message. Finally the postcards are processed through a Burster, where the marginal perforations are trimmed and the cards separated and stacked for mailing.

The following month's advance cards are now automatically reproduced by means of the Reproducing Summary Punch which is set up so that one month's present reading becomes the next month's previous reading in the advance billing cards. The accounting cards from which the postcard bills were run now become the accounts receivable cards. As the stubs from the postcard bills are received, indicating payment, the corresponding punched cards are pulled from the file and are later run through the accounting machines to prepare cash payment lists and balance. Cards remaining in the accounts receivable file after the expiration of a ten-day net-payment period are merged with their corresponding master name cards and the delinquent notices listed. Any cards remaining in the file for a given zone at the time of the next billing are considered as balance due cards and are included with the metered-water billing cards, so that a complete bill is printed each month.

FIG. 4. Alphabetical Accounting Machines

All delinquent notices are mailed in 3¢ envelopes.

The detailed cards which have served as billing and accounts receivable records will also be used for rate studies, revenue and consumption analyses and other valuable information. In addition to these studies, the master name and address cards will be used in preparing new meter books.

Figure 5 shows a portion of the offices of the Atlanta Water Works Billing Dept. Along the left wall, from front to rear, are arranged the Alphabetic Key Punch, the Interpreter, the Sorter, the Collator and the Reproducing Summary Punch. The two Alphabetical Accounting Machines, shown in Fig. 4, may be seen against the far wall, with a plugboard rack between them. To their right, also against the far wall but out of the picture, are the Imprinter and the Burster. At the right of the photograph are the control desk and filing cabinets. The row of cabinets separates the billing machines section from the mailroom.

FIG. 5. Billing Department Office

Postcard Bill

The postcard bill is a combination customer's bill and cashier's stub (Fig. 6). It is lightly perforated to facilitate stub removal. The customer portion of the postcard shows previous and present meter readings, cubic feet of water consumed, gross and net charges, net-bill payable date, inside and outside city rate, size of meter, number of rates and exact days of service rendered. A brief rate summary is also given in order that domestic users may calculate their own water bill. A charge code is included which indicates other miscellaneous charges for service rendered. On the stub side of the bill are the zone, book and page listing, the gross and

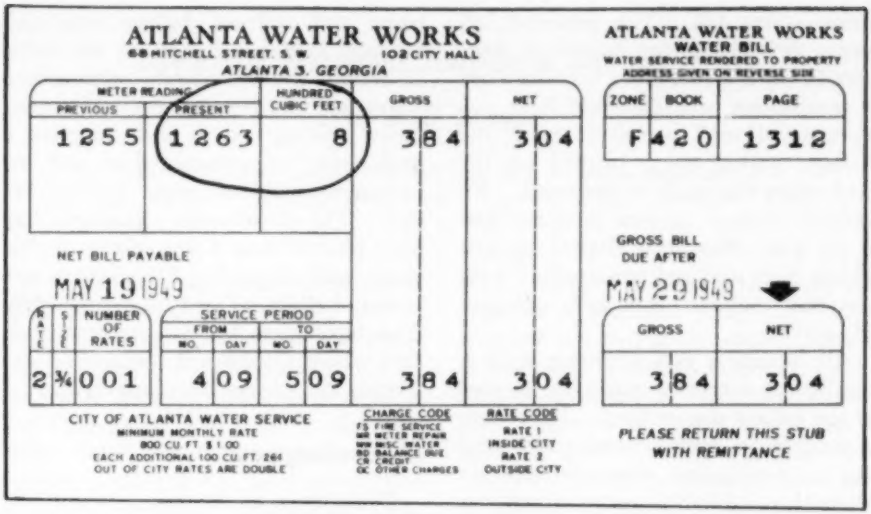


Fig. 6. Postcard Bill—Billing Side

net charges and the date after which the gross bill is due. The front side of the postcard, the address portion (Fig. 7), contains the name and address of the customer with a space for the service address if desired; the book and page is also indicated. On the stub portion of the front of the postcard is printed the monthly Willing Water message to the customer.

The postcard is of white paper stock, representing purity of water, and all printing is in blue, the color of water. The total result is a pleasing and utili-

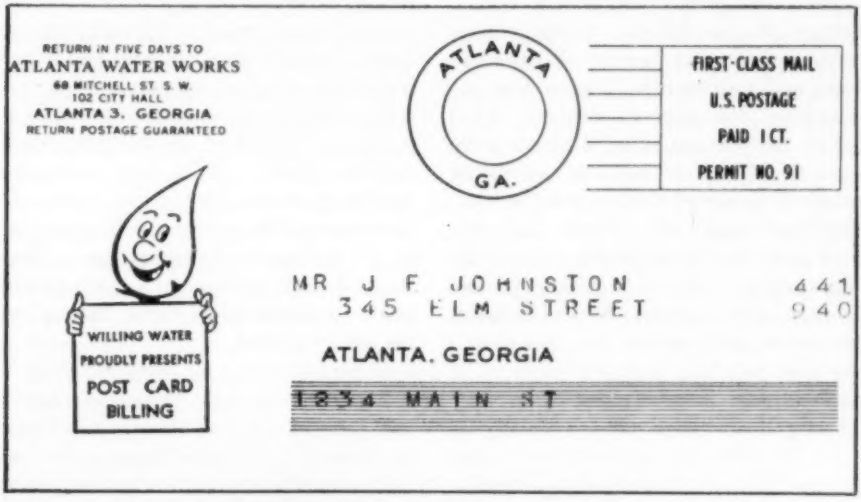


Fig. 7. Postcard Bill—Address Side

tarian water bill. The postcard bill forms, printed by the Standard Register Co. of Dayton, Ohio, are furnished in continuous, accordian-fold form. A nonmetered mail permit is used, the postage indicia being printed on the card when the stock is prepared. An advance postage account is established at the post office by a deposit against which daily mailings are applied, with one cent deducted for each postcard bill mailed.

All incoming and outgoing mail is handled at a central mailroom located in the billing department. This room is modern in every respect, and even has a mechanical envelope opener. More than 1,500,000 pieces of mail are handled annually. All mail, whether inbound or outbound, is weighed before processing, a precaution which has eliminated many errors. A relatively uniform schedule of work has been developed by handling inbound mail in the morning and outbound in the afternoon.

Conclusion

The IBM punch card system of the Atlanta Water Works is the cumulative result of a series of carefully timed and synchronized mechanical operations. Its success depends upon skilled technicians scheduling an even flow of billing throughout the entire month from meter readings to the completed postcard bill. Peaks and low work periods are materially reduced by this system. The new billing system automatically computes the bills, checks for errors and prints the customer's name and address, billing data and Willing Water message on the bills. It counts the customers, summarizes water use and revenue derived, copies meter reading sheets and compiles a multiplicity of valuable data and information with minimum manual effort. The department's business has been placed upon a new plane of efficiency and dispatch. All accounts are balanced daily, as in banking practice. The department believes its new postcard billing system will continue to win friends and please the taxpayer.

Acknowledgment

The success of the new postcard billing system has been due in large measure to the cooperation and enthusiasm of the Atlanta Water Works employees. John H. Cooper, veteran office manager, gave the project direction and the benefit of his many years of experience. Henry O. Coleman, auditor, contributed materially to the technical accounting development of the program. Tom H. Bird, associate auditor, was assigned to direct and supervise the entire conversion program. His enduring patience, sympathetic understanding and technical acumen established an enviable record of coordination seldom achieved. Herbert E. Harris, Mgr., Atlanta Office, IBM, and associates rendered invaluable service from the inception of the postcard billing system to its successful inauguration. Their counsel and knowledge of accounting were of inestimable value throughout the entire period.

Making Annual Reports Interesting

By E. B. Mayer

A paper presented on May 30, 1949, at the Annual Conference, Chicago, by E. B. Mayer, Exec. Engr., Dept. of Water & Power, Los Angeles.

AN annual report is an official statement of facts pertaining to the utility's activities and consists of many pages of printed matter, supported by diagrams, graphs, tables and pictures the purpose of which is to illustrate more clearly the subject matter of the report. Aside from laws or charter provisions requiring its publication, the most important reason for printing an annual report is its value from the administrative point of view: first, it records for historical and reference purposes the activities of the utility; and, second, it provides a medium through which public relations can be maintained.

It is evident, then, that an annual report should be carefully written and edited. The printing and publishing of an annual report should receive the same care as is given to engineering publications, for, in one sense, it *is* such a publication. The difference is that engineering publications are technical, dealing with practices, methods and procedures peculiar to the engineering profession, while an annual report deals with technical subjects and fiscal and historical data, which it records as a series of events having dramatic unity and interest.

Water utilities, as a rule, spend very little money on advertising the use and benefits of a pure and wholesome water. Compared with the amount of money and space spent to advertise particular brands of commercial products, water, despite its importance to the community and the many interesting features involved in its production and distribution, is almost forgotten in the field of advertising. Not that an annual report is to be used solely as a medium of advertising, but it is more important to tell the story of water and its benefits to mankind than to publicize unessential items.

Engineers see beauty in bridges, dams and skyscrapers, but, when it comes to the design and publishing of an annual report, they are more concerned with construction materials, structural details, factors of safety, costs and efficiency of operation. The automotive engineer, in designing the body for a car, will have beauty, functional appointments and safety in mind, all of which are attractive to the motoring public. It appears, then, that the present trend in design gives consideration not only to function but also to eye appeal. There seems no reason not to follow the trend and design an annual report that will be a thing of beauty as well as functional. Both of these factors influence the size, style and arrangement of the material that will make up the report. For this purpose an $8\frac{1}{2} \times 11$-in. brochure is ideal. It is most practical and the size and style lend themselves to the best arrangement of the text, maps, graphs, tables and pictures (*see* Fig. 1).

The Los Angeles Dept. of Water and Power has been faced with the same

FIG. 1. Two-Page Spread From Los Angeles Annual Report, 1947–48

problems as other utilities in publishing its annual report. For many years the water system's part of the report consisted of copies of the divisional reports, which were edited in an effort to eliminate duplication and controversial statements. This policy was not successful, however, for duplication was bound to occur unless some of the divisional reports were rewritten. For example, the design of a major project, such as a dam, filter plant or large water carrier and its appurtenances, involves many special engineering problems in mechanical, hydraulic, civil, sanitary and electrical engineering. Each of these different problems is assigned to the engineer specializing in that field, for preparation of plans, specifications and estimates. When he writes an annual report covering the activities of his division, he naturally will report on the progress of his portion of the work assignment. It is readily seen, therefore, that overlapping and repetition cannot be avoided in a compilation of divisional reports.

This difficulty has been overcome by placing the responsibility for writing and publishing the report in the hands of the publicity director. The first and second issues of the booklet—that is, the department's forty-sixth and forty-seventh annual reports, for the years ending June 30, 1947, and June 30, 1948—were very successful. They presented pertinent factual data on the operation of this utility in a manner understandable to the public at large. The detailed reports submitted by the various division heads, from which the brochure report was compiled, are on file and open to inspection and analysis by interested parties.

Regardless of the style and type of annual report adopted by the utility, its policy should also be to have divisional engineers file annual reports on the functional activities and personnel problems of their divisions, as, collectively, these reports reflect the overall efficiency of the utility's operations.

Content and Arrangement

It is not the purpose of this paper to design a report that would be standard for all utilities, but rather to offer suggestions on size, style and arrangement of material, as well as on some of the statistics which should be included.

The material to be printed should be factual and so arranged that all the information on any subject is readily available in one place in the report. An explanation of this point may be in order. For instance, suppose the utility has a major project under construction which will take several years to complete and includes tunnels, dams, reservoirs, generating plants and all their allied activities. Each year a progress report is printed in the annual report until the project is completed, at which time a completion report is published, usually showing the date the work was started, when it was completed, the capacity of the reservoir and generating plant, and when they were put into service. Now, if this completed report listed the volumes and page numbers of previous reports, the reference information would be available in one place. The same thing can be said about the statistics. Tables, graphs and diagrams can all be assembled (with an index for ready reference) following the printed matter rather than being interspersed throughout the report.

It is the author's opinion that the report should be published in two sections, the written portion in the front and the statistical portion in the back, thus affording the possibility of binding the statistical section separately, if desired.

The written portion of the report should contain a short history of the utility and its relationship to the city, county, state and federal governments, followed by a description of the utility's activities, together with interesting photographs, maps and diagrams to illustrate the more important items. The next few pages should be devoted to revenues, expense, balance sheets and pie diagrams to illustrate revenue and expense comparisons, (Fig. 2). the cost of water for different uses and many other items.

tion, construction or finance. With a volume of such information, it would be easy to demonstrate the safety of an investment in the utility or to inform the public of the necessity for a rate increase. The graphs, diagrams and tables included in this section should show the trend for a ten-year period (Fig. 3) or a multiple of ten years. Such periods of time furnish historical material for long-term planning.

Only those statistics which are essential and graphically depict the trend in the growth of the utility should be

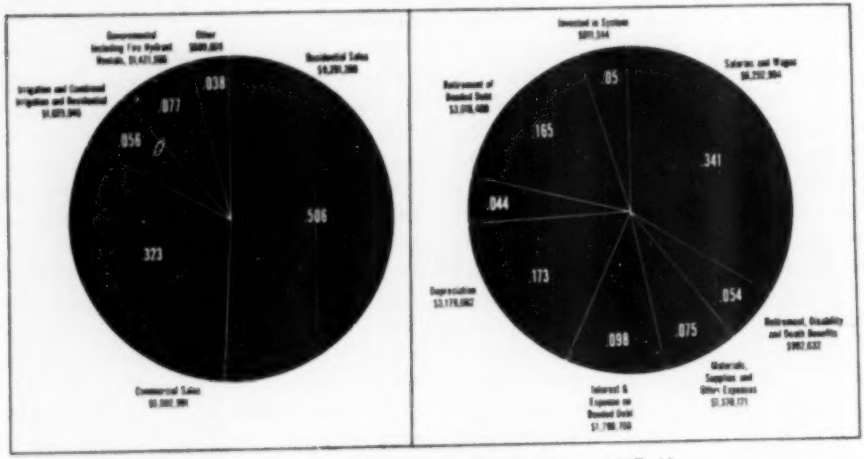


FIG. 2. Water Revenue and Expenditure, 1947–48

Statistical Section

Managers of water works generally are faced with the twin problems of long-term planning for additions and betterments to the plant and system, and the financing of such improvements either through revenues, which may require an increase in rates, or through some other source. For either purpose, adequate statistics are necessary; therefore, the statistical section should be designed with the thought of assisting managers in any problem related to the utility's activities, whether it be operaincluded in the report, such as the water main mileage and the number of gates, valves, fire hydrants, services and meters; the reservoir storage capacity; the quantity of water pumped; consumption by class; revenues and sales of water by class; operating and nonoperating expenses; and, possibly, maps showing areas of minimum and maximum consumption. Charts and tables should be omitted if the information does not have a direct bearing on the growth of the utility, such as data on the mileage driven by the transportation fleet or the number, make and

class of the units comprising it; the number of meters cleaned, checked and tested; the number of work orders issued and jobs finished by the different shops; the number of buildings painted and so forth. Although very important to the utility's division heads, superintendents, engineers and managers, these data really have no place in the annual report and only clutter it up, besides adding to the cost of publication.

Public Relations Value

Utility annual reports are distributed rather broadly, as copies are sent to libraries, colleges, schools, chambers of commerce, other utilities, consulting engineers, financial institutions and the general public. This list represents quite a cross section of opinion and provides a tremendous field for contacts to be made as well as for the improvement of public relations.

A few years ago the Los Angeles Dept. of Water and Power tried an experiment in public relations by issuing a little pamphlet entitled "Your Garden." Written in layman's language and published monthly for the prime purpose of encouraging home gardening, it carried information about the type and kind of fertilizer to be used, when to plant certain flowers and vegetables, and what to use in spraying flowers, shrubs, trees and rosebushes to control insects, mildew and fungus. The customer was sent a copy of this publication with his monthly water and light bill. It met with considerable enthusiasm from the very first issue. In fact, a number of different water companies and other utilities asked to be placed on the mailing list, and requests for copies were received from all over the world. The pamphlet did not increase revenues from the sale of water to any great extent, but it did build up a better feeling between the consumer and the utility. The public became conscious of the Dept. of Water and Power and the important role that water plays in everyday life. Because of this experience, the author feels sure that an annual report can be written and published which will receive the same kind of enthusiasm while conveying a very important message to the consumer public.

If the utility does not have a publicity director or an employee with a natural gift for report writing, it can, through cooperation with educational institutions, develop a policy covering production details that will be of benefit to both the school and the utility.

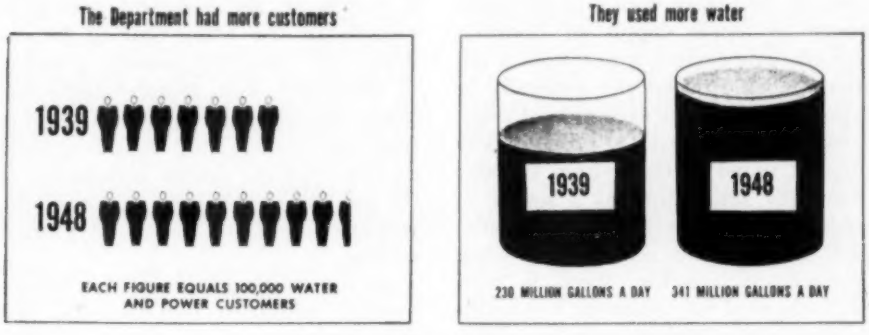


FIG. 3. A Decade of Growth

Well Pump Bearing Lubricants and Bacteriological Quality

By L. E. Ordelheide

A paper presented on June 3, 1949, at the Annual Conference, Chicago, by L. E. Ordelheide, Director, Section of Environmental Sanitation, Missouri Div. of Health, Jefferson City, Mo.

APPROXIMATELY 60 per cent of the municipalities in Missouri depend upon deep drilled wells as a source of public water supply. Most of the well supplies in Missouri are located in the Ozark region of the state, where an ample supply of bacteriologically safe ground water from a relatively deep stratum can generally be expected. With the exception of slight to moderate hardness, the ground water supplies found in this region are also chemically satisfactory as a source of public water supply. Consequently, with the exception of softening when economically feasible, there is usually little need for treatment to provide a satisfactory domestic supply.

The division of health has long realized that for a considerable period a large number of the state's public water supplies will not be provided with chemical treatment. Consequently, cognizance has been taken of the necessity for the proper construction and equipping of well facilities to assure a continued supply of safe water. In this connection there have been developed, with a number of revisions, the "Division of Health Recommended Minimum Requirements Covering Sanitary Construction Features of Drilled Wells and Installation of Power Pumping Equipment."

Briefly, these requirements provide for: [1] casing, with a proper weight of pipe, the wells to a safe depth, as recommended by the state geological survey, the recommended depth being determined by a review of the driller's log, an examination of drill cuttings and a review of the complete geological records of the water-bearing formations; [2] pressure cement grouting of the entire 4-in. annular space between the drill hole and the well casing from the casing point to the ground surface; [3] the proper installation of the pumping equipment on top of the well at a point above the natural ground surface.

In the development of the recommended minimum requirements, due consideration was given, among other things, to types of pumping equipment, including the question of pump bearing lubricants.

Item 13 of the U.S. Public Health Service *Manual for Public Ground Water Supplies* (1) provides that: "Pump bearings situated in any well below the pumproom floor or platform shall be lubricated with water of a safe sanitary quality." The item shall be deemed to have been satisfied when "pump bearings situated in any well below the pumproom floor or platform are lubricated with water taken from within the well, or reservoir or distribution system supplied with water from the original source of water supply, or from another supply which meets the

requirements of the health officer," or "in case of existing installations using oil-lubricated bearings, [when] the oil is stored and handled so as not to expose it to contamination."

This statement is practically identical with the statement made on this subject by the Committee on Ground Water Supplies of the Conference of State Sanitary Engineers in its 1936 report and with Sec. 4.44 of the A.W.W.A. "Tentative Manual of Safe Practices in Water Distribution" (2).

A review of the literature and inquiry of a number of official public health agencies failed either to substantiate or to contradict the theory that well pump lubricants had any effect upon the bacteriological quality of water supplies. Consequently, a questionnaire was prepared on the subject and sent to all of the state health departments. The questionnaire was designed to provide information on health department policies and experiences with regard to well pump bearing lubricants. An exceptionally good response to the questionnaire was received.

A summary of the information obtained in this manner indicated that most of the state health departments had not established a definite policy on the subject. Five departments reported that they approved only pumps with water-lubricated bearings. Four additional states indicated that pumps with either oil- or water-lubricated bearings were being approved but that the latter were preferred or being recommended. As might be expected, several states reported difficulties with each type of lubricant, which, for the most part, were confined to specific installations and could logically be attributed to faulty installations or the character of the water rather than to the nature of the particular lubricant.

The information obtained from the questionnaire and that provided by other sources clearly indicated a lack of definite data on the effect of well pump bearing lubricants upon the bacteriological quality of water supplies. This fact prompted a study of the Missouri Div. of Health records of public water supplies to determine the significant difference in the bacteriological records of wells equipped with pumps using oil- and water-lubricated bearings. Complete records are on file for each well employed as a source of public water supply, including date constructed, total depth, depth and diameter of casing, water-bearing formation, yield and other details, as well as the make, type and capacity of the well pump. Moreover, since water samples from each public water supply are submitted routinely to the state laboratory for bacteriological examination, the files contain a fairly long record of bacteriological analyses of such wells.

A careful analysis was made of the records of the wells serving public water supplies for the purpose of selecting those to be included in the study. Wells not depended upon as a safe source of supply and those with known sanitary defects requiring purification processes were automatically eliminated from the study. A total of 134 wells located in 95 cities was selected, of which 51, or 38.8 per cent, are equipped with water-lubricated pump bearings, while 83, or 61.2 per cent, have oil-lubricated bearings. The bacteriological study covered records over a period of eight years (1941–48, inclusive). A total of 4,861 samples collected during this time from the 134 wells was used in the study. Of this number, 1,760 samples, or 36.2 per cent of the total, were collected from wells with water-lubricated pumps, while 3,101 samples, or 63.8 per cent, were

taken from wells equipped with oil-lubricated pumps. All the samples considered were collected directly from taps on the pump discharge lines.

A summary of the bacteriological records of the samples over the eight-year period indicates that 1.85 per cent of the individual 10-ml. tubes of the oil-lubricated well samples were positive for *Esch. coli*, while 1.87 per cent of the tubes of the water-lubricated well samples were positive—thus showing no significant difference. *These data indicate that the lubricant of well pump bearings has essentially no effect upon the bacteriological quality of the water supply.*

It is believed that the data assembled in this study are as free as possible from factors which might influence the results. As previously mentioned, wells of known sanitary defects or those not depended upon as a safe source of supply were not included in the study. Furthermore, since all samples included in the study were recorded on the enclosed information card as being collected direct from a tap on the pump discharge, the results should not be affected by any contamination which may be present in a distribution system or storage reservoir. Finally, all of the samples in the study were examined in the central laboratory of the division of health in accordance with *Standard Methods*. The samples were collected by municipal water works personnel and by field engineers of the division of health. It is realized that some of them may have been carelessly taken, which might account for some of the contaminated samples, but it is believed that the number of wells represented in each category and the total number of samples are sufficiently large to provide compensation for this and for other possible unknown factors.

Consideration was also given to the possibility that either water- or oil-lubricated pumps might be more prevalent in specific areas of the state and that differences in the quality of ground water in the various areas might thus influence the bacteriological results obtained. An analysis was made of the distribution, over the nine division of health field districts, of deep well pumps using the two different lubricants, and a comparison of the bacteriological records by districts was also undertaken. No significant abnormalities were discovered.

Conclusions

1. This study was confined strictly to a comparison of bacteriological quality of water from wells equipped with pumps having oil- or water-lubricated bearings. No attempt was made to compare the relative merits of the two methods of lubrication with respect to mechanical efficiency, operational maintenance, adaptability under specific conditions and the like.

2. The number of wells included in this study, the number of samples involved and the period of time represented by the study are sufficient to compensate for unknown factors and to produce significant statistical data.

3. The summary and comparison of the bacteriological records of wells in Missouri equipped with pumps with oil- and water-lubricated bearings indicate that the type of pump bearing lubricant has no significant effect upon the bacteriological quality of the water supply.

References

1. Sanitation Manual for Ground Water Supplies. Pub. Health Repts., **59**:No. 5 (Feb. 4, 1944).
2. Tentative Manual of Safe Practice in Water Distribution—7J.1-T. Jour. A.W.W.A., **34**:915 (June 1942).

Effects of Synthetic-Detergent Pollution

By John T. Cross, William U. Gallaher, Joseph G. Filicky and John W. Hassler

A panel discussion presented on May 31, 1949, at the Annual Conference, Chicago, by John T. Cross, Prin. Filtration Chemist, South Dist. Filtration Plant, Chicago; William U. Gallaher, Plant Supt., Water Dept., Appleton, Wis.; Joseph G. Filicky, Industrial Chem. Sales Div., West Virginia Pulp & Paper Co., Tyrone, Pa.; and John W. Hassler, Director of Research, Industrial Chem. Sales Div., West Virginia Pulp & Paper Co., Tyrone, Pa.

Effect on Coagulation—*John T. Cross*

THIS paper will present a brief study of the effect of synthetic detergents on the coagulation of raw Lake Michigan water. Six synthetic detergents were used, of which three were domestic (designated: D_1, D_2, D_3) and three industrial (designated: I_1, I_2, I_3). The effect of these detergents on floc formation is but one phase of the rather comprehensive subject of coagulation enhancement or retardation by synthetic-detergent pollution. Countermeasures, being extremely specific and extensive, will not be discussed, as more work is required on this aspect of the problem.

From stock solutions of each detergent, prepared by weighing and diluting with distilled water, concentrations of 0.1, 1.0, 3.0 and 5.0 ppm. were made up using raw Lake Michigan water. Unless otherwise specified, the results discussed for any detergent may be considered to refer to a concentration of 5.0 ppm. Where poor coagulation took place in a concentration of less than 5.0 ppm., the concentration is specified. It may be noted that when interference in coagulation did occur, it usually did not come about until a concentration of 5.0 ppm. was reached.

Procedure

One-liter portions of raw Lake Michigan water, to which were added concentrations of 0.1, 1.0, 3.0 and 5.0 ppm. of a specific detergent, were agitated in 1,500-ml. beakers with a stirring machine. A fifteen-minute mixing period at a speed of 44 rpm. was adopted as being reasonably comparable to actual mixing at the South Dist. Filtration Plant. It is difficult to reproduce plant mixing conditions in the laboratory, but the jar tests will definitely differentiate between good and poor coagulation.

After the dilution of the detergent, the paddles were lowered and the agitation started. The chemicals were then added at fifteen-second intervals. Observation of the first formation of floc was noted and the time recorded. After five minutes the beakers were removed and viewed with a hand magnifying lens against the light of the laboratory window in order to study the appearance and size of the floc. At the

end of the fifteen-minute stirring period, the samples were allowed to settle for half an hour, at which time equal portions were withdrawn from the center of each mixture and the turbidity determined, by either a Baylis turbidimeter—for turbidities less than 2.0 ppm.—or a Cenco* sheared photolometer, for greater turbidities. Of the remaining portion of the sample, 500 ml. was passed through a cotton plug filter (Fig. 1) to see whether the coagulated water would filter clear. A turbidity reading was made on the filtrate. The pH was determined electrometrically immediately after mixing. A control sample of raw Lake Michigan water without a detergent was run concurrently with each set of detergents for the purpose of comparing and evaluating the resulting effects.

The classification of the character of coagulation was that used by Baylis in his extensive work on the subject:

J.V.—Just visible, small particles, slow settling

F.P.—Fine particles, readily discernible

F.—Fair, particles 0.2–0.3 mm. in size

F.G.—Fairly good, particles 0.3–0.5 mm. in size

G.—Good, particles 0.5–0.8 mm. in size

E.—Excellent, particles 1.0–1.5 mm. in size.

The coagulants used were: [1] alum, with and without lime; [2] alum and silicate; [3] ferric sulfate, with and without lime; and [4] chlorinated copperas, with and without lime.

As might be expected, the reaction of each detergent with a specific coagulant showed individual characteristics. Although, in general, the effects of interference were similar, there existed a marked differentiation in degree. The interference encountered may be broadly classified in two categories:

1. Sometimes the floc, after an initial formation classed as "just visible," would not coalesce, leaving considerable suspended colloidal matter, which would settle extremely slowly and would not filter clear through the cotton plug filter.

2. In other experiments, reasonably good floc formation would result, but there would still be considerable colloidal matter in suspension which would pass the cotton plug filter.

FIG. 1. Cotton Plug Filter

Summary of Results

1. The addition of lime produced a marked improvement in the coagulation of the detergent-treated raw water with all the coagulants used. For example, with alum alone as the coagulant, the pH after mixing was 7.60, the optimum for the coagulation of Lake Michigan

* Central Scientific Co., Chicago.

water. The addition of a small quantity of lime raised the pH to 7.90 (this practice is followed at the South Dist. Filtration Plant in order to deposit a small quantity of calcium carbonate in the distribution mains). With the alum and lime dosage, only two of the six detergents showed interference to any extent, whereas the chemical application of alum alone brought about a condition conducive to very poor coagulation with five of the six detergents. With the ferric salts coagulation when detergents are present. It may also be that the lime aids in the neutralization of the charge on the colloidal particles of the coagulant, whereas, in the absence of lime, the detergent produces a condition of particle repulsion instead of coalescence.

2. The domestic detergents resulted in considerable more interference with coagulation than the industrial detergents.

3. Without the addition of lime, alum-silicates gave better coagulation

TABLE 1

Alum Coagulation

Detergent (5 ppm.)	Time First Floc Formed *min.*		Appearance* at 5 min.		Turbidity After 30-min. Settling *ppm.*		Cotton Plug Filter Turbidity *ppm.*	
	With Lime	Without Lime	With Lime	Without Lime	With Lime	Without Lime	With Lime	Without Lime
D_1	2½	3	F.G.	J.V.	3	5	0.1	1.5
D_2	4	3	F.G.	J.V.	8	8	0.2	1.5
D_3	2½	1½	F.G.	J.V.	3	3	0.0	0.2
I_1	2	2	F.G.	J.V.	5	5	0.0	0.2
I_2	4	4	F.G.	F.P.	4	3	0.0	0.0
I_3	1½	2	F.G.	F.P.	8	1.5	0.0	0.5
Control	1½	1½	F.G.	F.P.	2.5	1.5	0.0	0.0

Raw Water	Chemical Dosages	
Turbidity—13 ppm. Temperature—16°C. pH—8.32	Alum—14.4 ppm. Lime—4.2 ppm. pH after mixing—7.85	Alum—14.4 ppm. Lime—none pH after mixing—7.60

* For explanation of abbreviations, *see* p. 18.

as coagulants, the pH without lime was 7.80 when 14.4 ppm. of coagulant was used, while the pH with the same dosage of coagulant, but with the addition of 13.8 ppm. of lime, was 9.10 after mixing. In the control sample, ferric salts at the low pH showed fair coagulation, but in the detergent-treated samples at this low pH very poor coagulation was noted. These data on the effect of lime may indicate that pH becomes a more important factor in in the presence of detergents than did the other coagulants tested.

Alum

As noted above, the characteristics of floc formation in the presence of a detergent, with alum as the coagulant, were found to be dependent on the addition of lime. When lime was added with the alum to give a pH of 7.90 after mixing, only two of the six detergents—D_1 and D_2, both domestic—

showed any marked interference with coagulation. Both of these detergents began to retard floc formation at a concentration of 3.0 ppm. The resulting floc was made up of fine particles less than 0.5 mm. in size which were slow to settle and did not filter clear through a cotton plug filter. The turbidity in the filtrates was 0.1 and 0.5 ppm., respectively. On the whole, the floc formed as rapidly as the control terference. The results of coagulation with alum are shown in Table 1.

Alum-Silicate

In the presence of a detergent, with alum as the coagulant, the use of silicate as the coagulant aid did not improve coagulation. When poor coagulation was present, it was usually detected at a detergent concentration of 3.0 ppm. and was very prominent at

TABLE 2

Alum-Silicate Coagulation

Detergent (5 ppm.)	Time First Floc Formed min.		Appearance* at 5 min.		Turbidity After 30-min. Settling ppm.		Cotton Plug Filter Turbidity ppm.	
	With Lime	Without Lime	With Lime	Without Lime	With Lime	Without Lime	With Lime	Without Lime
D_1	1½	3	J.V.	J.V.	3	1.5	0.2	0.2
D_2	1½	1½	J.V.	J.V.	3	3	0.2	0.2
D_3	1½	2	F.G.	F.	1	2	0.0	0.2
I_1	1½	2	F.G.	F.G.	1	2	0.0	0.0
I_2	1½	2	F.G.	F.G.	1	2	0.0	0.0
I_3	1½	2	F.G.	F.G.	1	2	0.0	0.2
Control	1½	1½	F.G.	F.G.	1	1	0.0	0.0

Raw Water	Chemical Dosages	
Turbidity—10 ppm. Temperature—15°C. pH—8.40	Alum—14 ppm. Silicate—1.4 ppm. Lime—4 ppm. pH after mixing—7.94	Alum—14 ppm. Silicate—1.4 ppm. Lime—none pH after mixing—7.62

* For explanation of abbreviations, *see* p. 18.

sample, but after visible formation did not increase appreciably in size.

The use of alum without lime, at the optimum pH of 7.60, gave very poor coagulation in the presence of detergents. The floc was of a very fine particle size—less than 0.3 mm.—and after initial visible formation did not coalesce but remained in suspension. The filtrate from the cotton plug filter ranged in turbidity from 0.2 to 1.5 ppm., with the domestic detergents D_1 and D_2 presenting the greatest in-

5.0 ppm. Concentrations of 10.8 ppm. alum and 1.2 ppm. silicate gave results comparable to concentrations of 14.3 and 1.2 ppm. alum and silicate, respectively, both combinations tending to give a very slow settling floc made up of small particles that did not filter clear. The domestic detergents all reacted in the same manner, but the industrial detergents I_1 and I_2 gave results comparable to the control sample, with a floc size of 1–2 mm. conducive to rapid settling (Table 2).

With one domestic detergent, D_2 (in a 5.0-ppm. concentration), a good characteristic silicate floc with a particle size of 1–2 mm. was formed, but considerable colloidal matter was left in suspension, so that after one-half hour of settling the filtrate of the cotton plug had a turbidity of 0.2 ppm. It was then observed that considerable floc was floating on the surface of the water. Closer observation with a hand magnifying lens showed the floc to be adsorbing minute air bubbles. With increased temperature, the small air bubbles would tend to rise to the surface, carrying the attached piece of floc. At the end of two hours' settling, with a temperature increase of 4°C., all the floc had risen to the surface. The same results were noted for detergent concentrations of 1.0 and 3.0 ppm. The floc of the 0.1-ppm. sample remained in the bottom of the beaker as did the control sample. An alum-silicate ratio of 7 : 1—14 ppm. alum and 2 ppm. silicate—gave the poorest coagulation with all the detergents with one exception, D_3, which produced a floc analogous to the control sample and did not in this ratio tend to give a rising or surface floc. At the 7 : 1 ratio, D_1 and D_2 in 5.0-ppm. concentrations gave a "just visible" floc and a cotton plug filtrate of 0.5 ppm. turbidity. The control sample at the ratio of 7 : 1 gave an excellent, rapidly settling floc, leaving a clear supernatant of only 0.8 ppm. turbidity at the end of a half-hour settling period. The cotton plug filtrate had zero turbidity.

TABLE 3

Ferric Sulfate Coagulation

Detergent (5 ppm.)	Time First Floc Formed *min.*		Appearance* at 5 min.		Turbidity After 30-min. Settling *ppm.*		Cotton Plug Filter Turbidity *ppm.*	
	With Lime	Without Lime	With Lime	Without Lime	With Lime	Without Lime	With Lime	Without Lime
D_1	3	2	F.P.	J.V.	2	7	0.0	1.0
D_2	3	2	F.P.	J.V.	6	5	0.2	1.5
D_3	2	2	F.P.	J.V.	2	3	0.0	0.2
I_1	2½	2	F.G.	F.P.	2	1.5	0.0	0.2
I_2	3	2	F.G.	F.P.	3	3	0.0	0.5
I_3	3	3	J.V.	F.P.	6	3	0.1	0.2
Control	2	2	F.G.	F.P.	2	1.5	0.0	0.2

Raw Water	Chemical Dosages	
Turbidity—10 ppm. Temperature—19°C. pH—8.40	Ferric sulfate—14.4 ppm. Lime—13.8 ppm. pH after mixing—9.00	Ferric sulfate—14.4 ppm. Lime—none pH after mixing—7.80

* For explanation of abbreviations, *see* p. 18.

Ferric Sulfate

The results of tests with ferric sulfate as a coagulant in the presence of synthetic detergents were similar to those found with alum. Interference was minimized when lime was added to bring the pH up to 9.10 or higher. When lime was not added, the pH

TABLE 4

Chlorinated Copperas Coagulation

Detergent (5 ppm.)	Time First Floc Formed min.		Appearance* at 5 min.		Turbidity After 30-min. Settling ppm.		Cotton Plug Filter Turbidity ppm.	
	With Lime	Without Lime	With Lime	Without Lime	With Lime	Without Lime	With Lime	Without Lime
D_1	2	2	F.G.	J.V.	1	5	0.1	1.5
D_2	2	2	F.G.	J.V.	2	3	0.0	1.5
D_3	2	2	E.	F.	3	1	0.0	0.0
I_1	2	2	E.	F.	3	1	0.0	0.2
I_2	2	3	E.	F.P.	1	2	0.1	0.0
I_3	2	2	E.	F.	3	6	0.0	0.4
Control	2	2	E.	F.	1	1	0.0	0.0

Raw Water	Chemical Dosages	
Turbidity—10 ppm. Temperature—17°C. pH—8.45	Chlorinated copperas—14.3 ppm. Lime—13.8 ppm. pH after mixing—9.0	Chlorinated copperas—14.3 ppm. Lime—none pH after mixing—7.90

* For explanation of abbreviations, see p. 18.

dropped to 7.80, resulting in the usual poor coalescence and considerable suspended colloidal matter which was very slow to settle. Without lime, two of the domestic detergents, D_1 and D_2, showed pronounced interference, producing a very fine particle formation which did not coalesce. The particle size would be classified as "just visible." The ferric sulfate added to give this type of reaction was 14.4 ppm. A ferric sulfate dosage of 7.2 ppm. gave a "just visible" floc that settled negligibly within a half hour, and an increase in the ferric sulfate dosage to 21.6 ppm. did not improve the situation. The other detergents left a fine colloidal floc in suspension that did not filter clear, as shown in Table 3.

Chlorinated Copperas

Using chlorinated copperas with lime added to give a high pH, only moderate interference was encountered, in the nature of a finely divided floc in suspension after a half hour of settling. Without lime, at a much lower pH, all the detergents except D_3 and I_2 showed considerable colloidal suspension and produced a very slowly settling floc. Consequently, two of the filtrates from the cotton plug filter showed a turbidity of 1.5 ppm. Table 4 gives the results of these tests.

Appleton Experience—*William U. Gallaher*

The Fox River water at Appleton, Wis., became difficult to coagulate in the lime softening process during the fall and winter months of 1948–49. This condition was noted by other treatment plants using the same source of supply. As the trouble with coagulation seemed greater than could be explained by the low-water conditions which prevailed at the time, the presence of detergents was suggested as a possible cause, since many sewage

plants reported that detergents had interfered with settling.

Municipal plants using Lake Winnebago and the Fox River as the source of supply employ carbon in large dosages. The normal maximum dosage during the summer is 40–80 ppm. and has reached 150 ppm. During the winter of 1948–49, however, a moldy or mildewy taste was noted in the water at irregular intervals. It resisted removal by activated carbon and was more pronounced at the consumers' taps than at the plant. This condition had not been experienced during previous periods of low stream flow and high algae counts in the river water. Therefore, the belief was strengthened that some substance was present in the raw water which had not been there before that time.

The raw river water at Appleton contains the primary treated sewage from two cities which are located only 5 miles up stream and which have a combined population of 25,000 persons. Moreover, Lake Winnebago, which feeds the Fox River, receives partially treated sewage from an additional 75,000 persons. This sewage contains detergents and the question was whether or not their concentration was sufficient to cause trouble since the wastes were considerably diluted by the time the water reached Appleton.

The determination of the compounds used as detergents would be difficult if not impossible in the concentrations present in the river water. Some calculations were therefore made on the basis of information contained in a recently published paper by T. E. Larson (1). Statistics indicate that the present annual consumption of deter gents amounts to approximately 4 lb. per capita, although this figure would seem to be low. If the 4-lb. figure is used, the amount of detergents used by the 100,000 people above the Appleton intake would be about 1,100 lb. per day. At times of low stream flow, the concentration of detergents could reach 0.25 ppm. If the total consumption reaches 5 billion pounds per year for the nation, the calculated concentration of detergents in the Fox River during low stream flow would be 3 ppm.

The above calculations have not taken into account many factors which will affect the final concentration of detergents in the water. There is a great deal of evaporation from the Lake Winnebago pool during the summer, which will tend to increase concentrations. Natural purification may decrease the concentration of polluting substances, although it is believed that the detergents will not settle because of their dispersing properties. Also, the industrial use of detergents, as well as the domestic use, will vary between communities.

It is the opinion of colloid chemists that 1 ppm. of tannates or sulfate wastes from pulp mills will adversely affect the coagulation of water. As detergents have surface tension–reducing properties similar to these compounds, they will probably affect coagulation when present in the amount of 1 ppm.

A rough demonstration of the effect of small amounts of detergent was made by adding "Surf" to distilled water and shaking. The time required for the bubbles to break on the surface is shown in Table 5. It will be seen that 1 ppm. of the detergent had a marked effect on the toughness of the bubbles and the effect increased rapidly with concentration. This experiment indicates that even a small amount of the detergent will interfere with coagu-

lation and settling, especially when the water contains little organic matter and requires small dosages of coagulant.

Operators have reported that, when the detergent "Dreft" was used in connection with chlorine, much better and faster results were obtained in the sterilization of new mains. The detergent lowered the surface tension of the mixture, allowing the chlorine to enter joint cracks and other places which the chlorine solution alone could not penetrate. Moreover, the detergent may loosen scale and other foreign material from the inside of the main and expose the surface beneath the scale to the chlorine.

TABLE 5

Effect of Detergent on Surface Tension

Detergent Quantity *ppm.*	Time for Bubbles to Break *sec.*
0	2±
1	9
2	11
3	24
4	60
5	110±

Detergents have been reported to cause bad tastes on reaction with chlorine. The elimination of a taste due to long-chain organic compounds may be more difficult than the elimination of tastes due to the reaction of phenolic compounds and chlorine. It would seem, however, that the same procedures might be successfully used to combat tastes due to detergents as are used for phenols. At Appleton, the use of 0.35–0.60 ppm. of sodium chlorite in connection with chlorine to form chlorine dioxide has resulted in the cessation of complaints of a mildewy taste in the water.

Reference

1. Larson, T. E. Synthetic Detergents. Jour. A.W.W.A., 41:315 (April 1949).

Effect on Palatability—*Joseph G. Filicky and John W. Hassler*

As the coagulation studies made by the authors were in general agreement with those presented by John T. Cross, the present paper will discuss the effects of synthetic detergents only on the palatability of water. The detergents studied are designated *A*, *B*, *C* and *D*, all but *A* being of the domestic type.

A 5-ppm. solution of each detergent was prepared and the threshold odor and taste values were determined by the procedure in *Standard Methods*. There is no direct correlation between the threshold odor and taste values (Table 6). Thus, with detergent *A*, a taste was observed at weaker dilutions than was the odor, whereas with *B*, *C* and *D* the reverse was true. It should be mentioned, however, that *B*, *C* and *D* appear to contain perfume, which could complicate the taste and odor relation.

In the next step, solutions of each detergent were prepared at a concentration sufficient to provide taste and odor values that were convenient to measure. These solutions were treated with a sufficient quantity of activated carbon * to give complete removal of tastes and odors. It should be mentioned that the detergent concentrations shown in Table 7 are probably higher than would be encountered in water supplies. Moreover, in order to provide a palatable water, it is seldom

* The activated carbon used was Aqua Nuchar, a product of Industrial Chemical Sales Div., West Virginia Pulp and Paper Co.

necessary to accomplish complete taste and odor removal as was done in this study.

With detergent *A*, the taste was more difficult to remove than the odor, whereas, with the other detergents, the reverse was true. Possibly the presence of perfume in detergents *B*, *C* and *D* contributes to this latter behavior.

Water containing each of the detergents was treated with chlorine in dosages ranging from 1 to 80 ppm. and was allowed to stand overnight, after which the samples were dechlorinated before determining the taste and odor values. In general, the tastes and odors were intensified and also altered in character. Thus, with detergent *A*, increasing chlorine dosages changed the odor from a soapy to a chemical and finally to a sour type. The taste changed from a bitter to a rancid type, which became more intense at higher chlorine dosages.

The action of chlorine dioxide was studied, using concentrations from 0.5 to 20.0 ppm. In general, the behavior paralleled that of chlorine.

The effect of the presence of lard on the tastes and odors of detergents was studied, using a ratio of 5 ppm. detergent to 10 ppm. lard. The lard made no change in the intensity of the taste and odor but did alter the type of the odor. Thus, the odor of detergent *C* changed from a soapy to a soapy-rancid type.

The tastes and odors of the detergent-lard mixtures can be removed by activated carbon,* but somewhat larger dosages are required than for the detergent alone.

The effect of chlorine, and also chlorine dioxide, on the detergent-lard mixtures was similar to that observed with solutions containing the detergent alone —that is, the type of taste and odor was altered and slightly intensified.

The tastes and odors were more difficult to adsorb after chlorination. Larger dosages of activated carbon * were required, which suggests that carbon should be applied before chlorination. This statement is true of both the detergent alone and the detergent-lard mixture.

TABLE 6

Comparison of Threshold Taste and Odor Values

Detergent*	Threshold Odor Value	Threshold Taste Value	Type of Taste
A	1	4	Bitter
B	18	7	Soapy
C	3	2	Bitter-soapy
D	5	0†	

* 5-ppm. concentration.
† No taste detected at concentrations below 30 ppm.

TABLE 7

Taste and Odor Removal

Detergent	Detergent Quantity in Original Solution *ppm.*	Activated Carbon Required—*ppm.*	
		Odor	Taste
A	7	4	15
B	5	30	10
C	10	15	7
D	40	40	10

* In these experiments, Aqua Nuchar FAN, a product of Industrial Chemical Sales Div., West Virginia Pulp and Paper Co., was used.

Effects of State Highway Construction Policies on Utility Installations

Panel Discussion

A panel discussion presented on May 30, 1949, at the Annual Conference, Chicago.

L. W. Grayson

Supt., Dept. of Public Utilities, Riverside, Calif.

THE great increase in population and motor vehicle registration in California during recent years has made necessary a vast program of highway construction. Many miles of state highways, once county roads and city streets, were made part of the state highway system so that the local governments could receive state aid. Until the 1930's utility installations occupying parts of these roadways were moved by joint agreement, either at utility or at state expense.

In 1936 the California Dept. of Public Works, having taken over a county highway, ordered the Marin Municipal Utilities Dist. to relocate a district water main to the outer edge of a newly acquired additional highway right-of-way. When the district refused to comply, the highway department moved the pipe and then brought suit in the name of the state to recover costs. A 1941 decision of the state supreme court sustained the highway department's contention that the expense of the relocation should be borne by the district. This case has often been referred to in the development of current policy.

During the war the highway program was retarded, but the population and vehicle registration figures rose. In November 1945 the Dept. of Public Works issued a tentative statement of policy on utility installations involving certain types of highways. Within a month the publicly and privately owned utilities of the state were holding committee meetings to discuss this statement. In June 1946 a definite policy was promulgated by the Div. of Highways. For the purpose of utility installations, highways were divided into three categories: [1] full freeways, [2] limited freeways and [3] full-access highways.

Policy Statement

Encroachment on freeways, including planted or landscaped areas, was prohibited. Utility structures encroaching longitudinally on limited freeways which might develop into full freeways were to be removed to the same distance as for full freeways. The 1946 policy statement limited transverse encroachment, in principle, to installations the operation and maintenance of which would in no way disturb or interrupt traffic flow. On a depressed freeway, it was required that crossings be made by means of an elevated structure.

A statewide committee of the California Municipal Utilities' Assn. studied the effect of this policy statement and developed a scientific approach to

a solution of the serious problems involved. The situation was particularly grave for some of the smaller communities which might be confronted with a need for water line relocation requiring dual mains and a capital outlay nearly equal to the total capital investment of the utility. A State Legislative Joint Interim Committee on Highways, Streets and Bridges was activated, before which substantial evidence was presented that the highway program entailed possible rate increases for some utilities while forcing others to issue bonds and incur heavy indebtedness.

Finally, in 1947, the problem was placed before the California State Legislature, and, after much controversy and discussion, was resolved by the passage of the Collier-Burns Highway Act of 1947.

Highway Act of 1947

Under this act, which amended the California Streets and Highways Code, utility occupation of freeways is given reasonable recognition, and relocation expense is generally made a part of highway costs. Furthermore, publicly owned utilities are, in some particulars, accorded a more liberal cost recovery program than that provided for privately owned systems.

Any utility required to move installations to a point outside the freeway right-of-way is to be reimbursed from state funds. The expense of relocation within a freeway is, for the publicly owned utility, a state cost, if the installation was in place before the highway became a part of the state system. If a similar move must be made by a privately owned utility, the state will assume the cost upon proof that the relocation is not a contractual obligation of the utility. Subsequent moves required by the state within a freeway right-of-way more than once during a ten-year period are to be paid for by the state. In any move to be paid for from state funds, depreciation, salvage and betterments must be credited to the state against the cost of the work completed. The act also provides that the state may advance the money for relocation or removal and provide for the work to be done if a utility is not financially able to bear the cost, on condition that the utility's portion of the expense is repaid to the state over a period not to exceed ten years.

Present Operating Policy

The present operating policy provides that the state, through the Div. of Highways, shall formally notify the affected utility to relocate or remove, setting forth the general parts of the utility system involved, the proposed location and the work schedule, and stating at whose expense the work will be completed and the authority supporting the notice. If a notice to relocate provides for state participation in the cost, a utilities agreement is drawn up, covering in detail the items involved, including the estimated cost to the state.

Provision is made for a joint-use agreement which recognizes the prior rights of utilities in the use of a common area when highway development extends in part or in whole to property over which the utility may have easements or other rights. In this situation, the agreement substantially provides for full state responsibility covering costs incurred by the utility resulting from damage done by the state or its contractors in the construction or main-

tenance of the highways. Alternatively, the state may, at its own expense, obtain a new right-of-way for a utility, the latter being then required to quitclaim the original right-of-way to the state.

It should be noted that the above discussion applies to utilities in freeways and not to those in other highways in the state system, or in county roads and city streets, which are covered by a franchise, permit or agreement that may contain a contractual obligation on the part of the utility involved in construction.

William G. Banks

Div. Engr., Div. of Water, Newark, N.J.

The extensive development of arterial road systems by the states has brought about a situation requiring full cooperation between the utility and highway authorities whenever the utility desires to cross the highway with its structures, or the highway department changes the alignment or grade of an existing highway, necessitating alterations in the utility's structures.

The New Jersey Highway Dept., which builds and maintains the highway system in the state, has established policies governing public utility structures on highways, freeways and parkways. *Highway* is a regular state road; *freeway* is a state highway "especially designed for through mixed traffic over which abutters have no easement or right of light, air or direct access, by reason of the fact that their property abuts upon such way, with infrequent public entrances and exits and with or without service roads; *parkway* is a state highway especially designed for through passenger traffic over which abutters have no easement or right of light, air or direct access, by reason of the fact that their property abuts upon such way, with special treatment in landscaping, etc." (Chap. 461, N.J. Laws 1948).

Generally, the crossing of a highway with a public utility structure, such as a water main, occurs along an intersecting street. The problem then is to maintain highway traffic during the construction of the water main and to construct the main in such a way that the operation and maintenance of the utility will not interrupt traffic.

The use of sleeves or special culverts or galleries to carry large-size cast-iron transmission mains under the highway is the usual practice. The utility is required to make application to the New Jersey Highway Commission for permission to make the crossing, and, if approved, the commission will issue a permit for the construction. The cost of restoring the pavement is borne by the utility.

When the highway commission makes changes in the alignment and grade of an existing highway under which utility structures are located, the state reimburses the utility for the cost of all the work required for the relocation and alteration of water mains and appurtenances made necessary by the reconstruction of the highway. This procedure applies also when the highway commission desires to remove the water mains and appurtenances outside of their proposed pavement area. The cost of building any water mains and appurtenances which are an improvement and betterment to the system is borne by the utility.

Highway Commission Policies

Some of the policies pertaining to water supply structures established by

the commission for freeways and parkways provide:

1. That all new utilities, both aerial and underground, located longitudinally with the highway shall be excluded from permanent freeway and parkway right-of-ways.

2. The Freeway and Parkway Acts provide that the state shall pay for the relocation of existing public utility facilities disturbed by freeway and parkway construction. This provision will not apply if the disturbance is occasioned for the convenience of the contractor.

3. The following principles shall be applied in the relocation of existing public utility facilities, which include pipes, mains, conduits, cables, wires, towers, poles and other equipment or plant:

a. It is desired that utility construction shall be made at grade separation structures and not under the freeway and parkway between such separation structures.

b. When it becomes necessary to locate utility construction between the grade separations or stream structures, such construction shall be underground, and manholes or points of access shall be located outside the permanent right-of-way. Situations requiring large, heavy structures to accommodate the utility facility under the parkway or freeway shall be subject to special study and individual decision.

c. Water facilities passing under freeway and parkway roadways shall be constructed of extra-long-life materials not subject to leakage. Valves shall be installed on each side beyond the permanent right-of-way limits. All appurtenances shall be located outside the right-of-way.

d. Where large water pipe facilities are involved, special galleries of suitable design and size shall be considered, having due regard to maintenance and replacement problems.

e. Where the freeway or parkway crosses pipelines involving no structures, and where the grade elevation of the line is such that it need not be relocated, the pipeline shall be rehabilitated, if required, with long-life materials of adequate strength.

f. Where it has been determined as necessary for a pipeline to cross under a freeway or parkway (other than at bridges), the crossing shall be made as nearly normal to the freeway or parkway centerline as possible. Long, diagonal crossings are not desired.

g. Existing water mains which cross the freeway or parkway right-of-ways at a number of points within the same general area shall be combined so far as practicable to reduce to a minimum the total number of crossings. This procedure will involve payment by the state for relocation work at places other than the site of the freeway or parkway when it can be demonstrated that such a combination of crossings is the preferable method.

h. In relocating and rehabilitating utility facilities with new materials, the utility shall make due monetary allowance to the state for the deteriorated value of the replaced materials.

Special problems will be the subject of special study, consideration and individual decision.

Relocation of Newark Mains

As a result of the policy of the New Jersey Highway Dept., the Newark Div. of Water has been required, during the past fifteen years, to relocate water mains at five different places on

account of highway construction. Two projects, involving the relocation of large transmission mains (42-, 48- and 60-in. in diameter) were carried out by state highway department contractors under the specifications of the Newark Div. of Water, incorporated by the highway department in its contract documents. The other three projects, including a 24-in. main crossing under the highway in a gallery and alterations made necessary by changes in alignment of the highways, were executed under contract by the Newark Div. of Water, later reimbursed by the highway department. All of the projects were covered by written agreements.

In connection with new highway construction, the division of water is often obliged to install facilities which may not be used for a long time, and a few may never be used. Such is the price of progress and preparedness.

Relations with the New Jersey Highway Dept. have been most harmonious and there has been the fullest cooperation by both parties, to the end that the safest and best type of construction shall result.

Arthur C. King

Supt., Water Works, Taunton, Mass.

A discussion of the effects of highway construction policies on water systems seems very timely, considering the stepping up of highway improvement activity throughout the country at all levels, from federal superhighways down to small-town roads.

State rules and regulations governing the maintenance of utility systems do not usually present serious problems in Massachusetts, possibly because the engineers are quite cooperative. The regulations may say that no new pavement shall be opened for five years, but the authorities realize that a leak in a water system must of necessity be repaired, regardless of the age of the pavement. So, too, pavements must be opened if that becomes necessary for the installation of service to new buildings.

An official permit must be procured before the pavement is opened, however, except in emergencies, when the permit may be procured later for the record. The permit issued may dictate conditions or methods to be followed, such as pushing pipe beneath a pavement instead of tunneling or excavating. The surface disturbed must be restored to the satisfaction of the state maintenance engineer.

Construction Problems

In general, the construction of a highway in a new location perhaps causes fewer changes in water systems than the straightening, widening and grade changing incident to the improvement of existing highways. On the other hand, if a new location bypasses the builtup section of a town but intersects a main which is the sole carrier of water for the whole community, the water works management may be faced with a serious problem, not because of the magnitude or expense of the work, but because of the difficulty of maintaining an adequate and dependable supply while changes are being carried out.

The same difficulty, in aggravated form, often arises when highway construction, either in a new location or because of improvements, follows the general direction of a supply main but does not parallel it. If the main is in good condition and adequate for the

demand in the foreseeable future, the problem may assume considerable proportions.

Widening an existing highway or constructing a broad, new one brings up the question of how best to provide water service, presently and in the future, on both sides of the highway. Present domestic water needs may readily be met, even though it is costly, by the installation of services crossing under the highway. Fire hydrants may also be installed on both sides to avoid the obstruction of traffic, in the event of fire, by lines of hose across the pavement.

Providing for future domestic and industrial service is another matter. This problem is frequently taken care of by installing a main of proper size on one side of the highway to supply hydrants on both sides. Then sections of smaller parallel mains are installed as required between the hydrants on the opposite side from the large main. These parallel mains need not be laid until the need materializes. This need, of course, may or may not be immediate, depending on the kind of property located along the highway.

Financial Responsibility

Perhaps the first, and often the most difficult, question to answer is: "Upon whom does the financial responsibility rest?" The second question, not quite as serious now as a few years ago, is usually: "How can the necessary stock of pipe, hydrants, gate valves and so forth be procured in time, if not already on hand?" Then a third question arises: "Who shall perform the actual work, regardless of allocation of cost?"

In Massachusetts a large amount of highway work is carried out under a divided financial responsibility. This is not strictly state highway construction but is called "Chapter 90" work, after the legislative act authorizing a division of cost among the state, county and town, the word "town" being used to denote either a city or a town. This arrangement is somewhat comparable to federally aided secondary-system projects in some states. Usually the division is 50 per cent from the state and 25 per cent each from the county and the town. Sometimes the county does not join in the project, and the cost is equally divided between the state and the town. For these Chapter 90 projects, the state plans the work and furnishes the engineering for the construction, and the county or the town makes any required expropriation of land in addition to paying its respective proportion of the construction costs. The suggested project layout is officially adopted by the county or the town before proposals for construction are requested. Contracts are awarded by the town with the advice of the state.

Private utility companies, whether telephone, electric, gas or water, are required to make any necessary changes in their own systems at their own expense and, since the towns are participants in the sponsorship of the projects, the publicly owned utilities are also required to perform the work and bear the expense of changes in their systems. In some Chapter 90 contracts, changes in utility systems are included in the specifications as "nonparticipating" items, for which the utility pays the contractor directly.

In contrast to Chapter 90 work, projects for principal highways which are built or improved with federal aid include, in the contract specifications,

provision for changes in utility systems to be made by the contractor. This procedure seems to be more equitable and businesslike since the contract figures thereby include all the expense of the project instead of concealing part of it in the general cost of operation of the utilities, whether privately or publicly owned.

Timing Difficulties

Because the authority of the state outranks that of the town, it becomes mandatory for the latter to perform the work entailed by the project layout accepted. Most publicly owned water systems are obligated to operate under the budget plan of the town and have no funds other than the yearly appropriations. Thus an extra expense added later in the year than the town meeting or the adoption of the budget obliges the water works to do certain work without an appropriation to cover the cost. In Massachusetts, therefore, the timing of the state highway work is a most difficult problem to solve.

The state engineers have studies and plans ready for the improvement and construction of many highways, but the work to be done in any particular year is not decided upon until that year arrives. In fact, no one can feel sure when a certain job will be done until the construction contract is actually awarded. Then the contractor is called upon to start work within a few days, and the utilities are expected, or at least requested, to have the necessary changes in their systems made at once. The contractors and the utilities are immediately in conflict and in one another's way. The contractor provides himself with an alibi in advance by complaining that the utilities are delaying his work, and the utilities are hard pressed to take care of this extra work along with their planned program. It seems that there is no solution for this difficulty, as circumstances may bring postponement of the work even after bids have been received. If the utilities have made the changes in advance, their labor and expense may be in vain. Some pipes may be left with too little cover, others far deeper than necessary; hydrants may be in strange, perhaps dangerous, locations; and the old street surface may have been unnecessarily destroyed by cross excavations. It simply does not seem feasible to try to get the work done early.

The state engineers and the better contractors, however, are usually cooperative and will meet the utilities halfway in their efforts to push the entire project to completion, but there still remains the problem of expenses not included in the budget.

Advances in Chemical and Colorimetric Methods

By J. J. Connors

A paper presented on Oct. 27, 1949, at the California Section Meeting, Sacramento, Calif., by J. J. Connors, Bacteriologist-Chemist, East Bay Municipal Utility Dist., Oakland, Calif.

IT is not the intent of this paper to present an exhaustive review of recent advances in analysis, as Love (1) has performed this service. Many improvements have been made in existing techniques since Love's survey, and mention will be made of a few of these at the end of the paper. For the most part, however, emphasis will be placed on the new and, to the water analyst, very important methods developed by Schwarzenbach for the determination of the calcium hardness and total hardness of water by simple titrations, and the calculation of magnesium hardness by difference. These methods, published in the last four years, are of impressive simplicity and accuracy, but the interferences are not all known and accounted for and some work remains to be done. Nevertheless, the methods appear susceptible of refinement, and there seems little doubt that in a relatively short time they will replace the present methods for the routine determination of the hardness of water, including, perhaps, the usual gravimetric analysis.

Since 1945 Schwarzenbach, of the University of Zurich, together with a number of collaborators, has published a series of related papers dealing with various organic compounds which form complexes with metal ions, particularly the alkaline earths (2). In the course of his investigations, he discovered that one complex-former in particular, ethylenediaminetetraacetic acid (also known in the United States by various trade names and referred to hereafter as versene *) formed stable, colorless complexes with calcium and magnesium, hydrogen ions being released from the complex-former in proportion to the amount of calcium and magnesium present. In his original work, he titrated calcium and magnesium with versene and determined the endpoint of the reaction from pH changes resulting from the release of hydrogen ions. Later it was found that a dye, Eriochrome black T, also known as F241, formed colored complexes with both calcium and magnesium at pH 10, the color being wine-red while the dye itself is blue. Since versene will remove calcium and magnesium from complexes with the dye, a titration can be performed with this reagent, the endpoint color change being from wine-red to blue. Calcium is reported (2) to form a weak, unstable complex with the dye which does not permit solutions containing only calcium to be titrated with versene alone. If a little magnesium is added to the versene, however, the endpoint marks the final removal of magnesium from the dye, and calcium solutions can be titrated successfully. It has been stated that the conditions of the test can be modified in such a way that calcium yields a better endpoint than magnesium.

* Trademark controlled by Bersworth Chemical Co., Framingham, Mass.

The reagents required for this titration are the dye, the complex-former and a buffer of pH 10 which is easily prepared.*

Total-Hardness Determination

[Note: The author's description of the procedure for total-hardness determination is omitted, as detailed directions for preparing the reagents and making the tests are given in this issue of the JOURNAL by Diehl, Goetz and Hach (p. 40) and by Betz and Noll (p. 49). Connors' discussion of the necessity for precise color comparisons and the effects of interfering materials follows.—*Ed.*]

Although color comparisons have not generally been considered necessary in this determination, the East Bay Dist. laboratories have found them highly desirable in accurate work, particularly under variable lighting conditions. The endpoint is sharp, but there is a range of intensity in which a selection must be made. Consistency of choice is more important than the exact color chosen as the endpoint. It has been found that there are slight qualitative differences in the endpoints, depending on the reagents used, their concentrations and, apparently, the hardness of the sample tested. For these reasons, no rigid specifications for color comparisons can be given, but it may be mentioned that, because of the possibility of contamination, as well as instability, artificial standards are less troublesome than those prepared from the reagents with calcium and magnesium excluded. One drop of bromophenol blue indicator solution in 50 ml. of saturated borax solution has been found useful when low concentrations of the dye are employed. In any event, it is believed that attention to such details will make the determination more accurate than it is now claimed to be.

Diehl, Goetz and Hach report the accuracy of this method to be within 2 ppm. of the actual total hardness as calcium carbonate, and the method has been applied to waters with a total hardness of 1,400 ppm. Experience in district laboratories indicates that, in its present state of development, the method will not yield accuracy of this degree with all waters (see below). Betz and Noll report an overall accuracy within 2 per cent and an error of only 0.1 ppm. in the hardness range 0.0–2.0 ppm. by employing a special technique.

The author, when applying the method to certain treated waters, found that no endpoint could be reached because of traces of copper remaining from the treatment of reservoirs with copper sulfate. The versenate presumably was not able to remove the copper from its complex with the dye, and, since the copper-dye complex is colored similarly to the magnesium-dye complex, the red color could not be discharged. It was found that by adding sodium diethyldithiocarbamate to the buffer solution the copper could be tied up and the interference avoided. This information was communicated to the supplier of the reagents, who subsequently marketed a modified dye which permits the titration to be performed in the presence of copper.

Iron is reported by Diehl, Goetz and Hach to precipitate the dye unless the buffer solution is added to the sample before the indicator.

Manganese also interferes with the titration, the effect apparently being a catalytic one resulting in fading of the color of the magnesium-dye complex. As little as 0.01 ppm. manganese

* References to sources of the reagents will be found on p. 39.

will cause fading overnight, but interference does not become important under ordinary conditions until the concentration of manganese exceeds 0.1 ppm. Rossum and Villaruz (3) have avoided this interference by exposing the buffered sample to the atmosphere for several hours before titration. The author has avoided the interference by oxidizing the manganese with chlorine water and boiling out the excess chlorine, a method which requires some care to prevent reduction of the manganese by boiling. These methods are of less interest now that a modified indicator is available which, according to Diehl, Goetz and Hach, permits the titration to be performed in the presence of 20 ppm. manganese. Another method, reported by Betz and Noll, involves the use of a buffer containing sodium sulfide which obviates the copper, manganese and iron interferences.

An interference not previously reported has been observed very recently in the district laboratories. The effect of the interfering agent is to lower the total hardness as found by the Schwarzenbach titration. Silica in large amounts is suspected, but the evidence so far collected is not conclusive. Whatever the source may be, the interference can usually be overcome by dilution.

It is clear that any agent which serves to sequester either calcium or magnesium will cause low results to be obtained if the sequestering action is greater than the complexing action of versene or of the indicator. This effect probably accounts for occasional large errors in determinations made on undiluted samples. In all strange waters such errors are best detected by titrating a 50-ml. portion without dilution and a 20-ml. portion diluted to 50 ml. with distilled water. If the results differ by more than 2 ppm. of hardness, the diluted portion is likely to be the more dependable. The causes of such errors are being investigated.

The waters analyzed in the district laboratories yield total hardness values (by the Schwarzenbach titration) which are lower by about 2 per cent than the values given by careful gravimetric analyses. Ingols and Murray (4) have shown that even very careful gravimetric calcium determinations made in accordance with *Standard Methods* usually will yield high values, due principally to occlusion of sulfate. They believe the sulfate is included as part of the calcium oxalate crystal. In most natural waters, increasing hardness will be accompanied by increasing sulfate concentrations, and it is quite possible that the error will approximate 2 per cent. Calcium values determined by titration with permanganate may also be too high because of excess oxalate. Some very careful work will be required to clarify this uncertain situation. It is interesting that, although Betz and Noll state the accuracy of the Schwarzenbach method to be within 2 per cent, their data suggest a much greater accuracy when artificial solutions are tested. It seems likely that their 2 per cent figure resulted from analyses of natural waters, the "true" hardness of which had been determined gravimetrically.

Calcium Determination

When a solution containing both calcium and magnesium is titrated with versenate in the presence of Eriochrome black T, the calcium is removed from its complex with the dye before the magnesium. No indication of the removal of the last of the calcium can be observed, however, and a "calcium endpoint" cannot be determined. If one can remove the calcium, the re-

maining magnesium can be titrated and the calcium obtained by difference (total hardness minus magnesium hardness). Rossum and Villaruz (3) have described a technique for precipitating the calcium as calcium oxalate and filtering; the filtrate is then titrated with versenate for the magnesium hardness. The author investigated this procedure independently and secured results similar to those of Rossum and Villaruz, who point out the necessity to filter off the precipitated calcium oxalate. This requirement makes the procedure much less desirable.

On consulting the original publications of Schwarzenbach (2) it was learned that he had investigated the compound ammonium acid purpurate, or murexide, and had found that it formed a colored complex with calcium but not with magnesium. Versene will remove the calcium from the calcium-murexide complex, and hence murexide can be employed for the determination of calcium hardness in the same manner as Eriochrome black T is employed for the determination of total hardness. Sodium hydroxide is used to attain the necessary pH, and the color change is from red-violet to violet.

Inquiry disclosed that murexide is not available commercially in this country, but its synthesis is supposedly not difficult (5). A small sample, purchased in Germany before World War I, was obtained, and some investigations have been conducted with it. The following observations can be made on these studies, with the reservation that they may not apply to other samples of murexide:

1. The murexide is employed as a saturated aqueous solution. The solution is unstable (as the solid is reputed to be) and, when not kept in contact with the solid, has decomposed in a time as short as two days. Saturated solutions in contact with the solid, however, have remained usable for more than a week. Since Schwarzenbach seems not to emphasize the instability of the compound, one may expect that sufficient demand will make stable forms of the reagent available.

2. A separate standardization is required for the determination of calcium. A versenate solution, 1 ml. of which is equivalent to 1 mg. of calcium carbonate when Eriochrome black T is employed as the indicator, will be equivalent to about 1.05 mg. calcium carbonate when murexide is used as the calcium indicator. This discrepancy may be due to the particular lot of murexide employed.

TABLE 1

Calcium Determination

Gravimetric Analysis		Versenate and Murexide Titration
Total Hardness *ppm.*	Ca *ppm.*	Ca *ppm.*
95	23.0	23.2
54	15.0	15.2
30	9.3	8.4
191	45.0	43.6

3. Copper in a concentration of 1 ppm. does not interfere (except to increase the hardness obtained) nor does manganese, which, when present in a concentration of about 5 ppm., is precipitated by the sodium hydroxide.

4. Time has not permitted sufficient work to justify positive statements about the accuracy possible, but the indications are that an accuracy within approximately 2 ppm. of calcium carbonate hardness can be obtained.

Table 1 shows some selected results on waters analyzed gravimetrically in another laboratory.

5. The use of a color comparison is imperative if accurate results are to be secured. The color change at the endpoint is not comparable in clarity to that obtained in the determination of total hardness with Eriochrome black T.

Reagents

The following reagents are used:

1. *Complexing reagent.* Use a versenate solution as in total-hardness determination.

2. *Alkali solution.* Schwarzenbach recommends 10 ml. of 1 *N* sodium hydroxide for a 200-ml. sample. For routine determinations, a 50-ml. sample will be found more convenient, and 2.5 ml. of 1 *N* sodium hydroxide will suffice. The following have also been employed for 50-ml. samples: [1] 0.6 ml. of 4 *N* sodium hydroxide or [2] 1.0 ml. of a mixture of equal parts of 4 *N* sodium hydroxide and saturated sodium tetraborate solution.

3. *Indicator solution.* Saturated aqueous solution of ammonium acid purpurate (murexide), containing a small amount of undissolved murexide. The supernatant should be used.

4. *Standard calcium chloride solution.* Dissolve 1.000 g. cp. calcium carbonate with a small amount of dilute hydrochloric acid, being careful to avoid spattering. Wash down with distilled water and neutralize the solution with dilute ammonium hydroxide to slight alkalinity, using litmus as an indicator. Make up to 1 l. with distilled water and store in a glass-stoppered bottle; 1 ml. of this solution is equivalent to 1 mg. calcium carbonate.

5. *Color comparison.* Two drops of cresol red indicator solution (as used in pH determinations) in 60 ml. of saturated borax solution.

Standardization of Complexing Reagent

Pipet accurately 20 ml. of standard calcium chloride solution into a casserole. Add 0.6 ml. of 4 *N* sodium hydroxide and five drops of the murexide indicator solution. Add the versenate from a buret until the color of the solution matches that of the color standard. It will be found more convenient to employ the same versenate solution as for the total-hardness determination and to use a factor.

Test Procedure

Measure 50 ml. of the sample in a graduated cylinder. Pour about 40 ml. into a casserole and add 0.6 ml. of 4 *N* sodium hydroxide and five drops of murexide indicator. Add versene solution until the color of the sample matches the color standard. Add the remaining portion of the sample and again titrate slowly until the color of the sample matches the color standard. Schwarzenbach recommends that the titration should not be delayed unduly because of the possibility of calcium carbonate precipitating.

Other Recent Advances

Although, as mentioned previously, no exhaustive attempt will be made to assess the numerous publications that may be of interest to the water works field, there are a number of papers which have caught the author's attention and perhaps deserve further study. Among these are Ayres' (6) critical analysis of photometry and the accuracy to be expected from photometric techniques. His discussion of the theoretical bases for evaluating the results of photometric analyses, and particularly the enormous errors which

may come from improper application of photometry, deserve consideration by all persons using these techniques without extensive knowledge of the theory involved. In the light of Ayres' paper, it appears that the results of West and Compere (7) were secured at the expense of recognized photometric principles.

The attractiveness of the flame photometer as a means of determining sodium and potassium is greatly enhanced by the intelligence that the very large errors involved are due largely to improper instrument design which is remediable (8). The most desirable range is found to be 0–10 ppm., allowing water to be analyzed without concentration. Smaller laboratories will no doubt find Rossum's (9) method of calculating sodium from conductance data more practical. The same investigator has also employed conductance data for checking the accuracy of water analyses (10). Lamar (11) has attacked the difficult problem of determining the color of turbid waters by using an electrolyte (calcium chloride) to precipitate the turbidity. Taras continues his researches on alkalinity indicators and has recently presented another indicator for carbonate alkalinity (12).

An example of the many painstaking improvements made in well known procedures is the work of Ingols and Murray (4), who have shown that the precipitation of calcium as calcium oxalate can be made more accurate by employing the hydrolysis of urea to raise the pH sufficiently to permit the formation of the crystals. The procedure results in much larger crystals and less occlusion, particularly of sulfate.

The experience gained in the preparation of this paper has convinced the author that the communication of useful information in the field of water analysis requires a less formal medium than a full-length article in the JOURNAL or other publications. The need for accumulating a reasonable amount of data before publication can easily result in the withholding of information of considerable value. It seems likely that the rapidly increasing amount of work with the Schwarzenbach methods will produce a great deal of important information that will take much too long in dissemination. It is suggested that an informal but regular means of communication be organized on a Sectional basis, with, perhaps, some coordination being provided by the A.W.W.A. on a national basis. Water analysts must be encouraged to report their failures as well as their successes, the former frequently being more enlightening than the latter.

Acknowledgment

The author is indebted to Henry Rapoport, of the Dept. of Chemistry, University of California, for supplying the murexide used in these investigations; and to Brown and Wilcox, of the firm of Brown and Caldwell, and Merle Foreman, California State Water Chemist, for supplying gravimetrically analyzed waters.

References

1. LOVE, S. K. Water Analysis (*review*). Anal. Chem., **21**:278 (1949).
2. SCHWARZENBACH, G. ET AL. Helv. Chim. Acta, **28**:828, 1133 (1945); **29**:364, 811 (1946); **30**:1303, 1798 (1947); **31**:331, 456, 459, 678, 1029 (1948); **32**:839, 1046, 1175, 1314, 1484, 1543, 1682 (1949); Chimia, **2**:56 (1948) (*all in German*).
3. ROSSUM, J. R. & VILLARUZ, PRIMO. Rapid Methods for Total Hardness in Water. Wtr. & Sew. Wks., **96**:391 (1949).
4. INGOLS, R. S. & MURRAY, P. E. Urea Hydrolysis for Precipitating Calcium Oxalate. Anal. Chem., **21**:525 (1949).
5. HARTLEY, WALTER NOEL. The Preparation of Murexide From Alloxantin

and Alloxan. Jour. Chem. Soc. Lond., **87**:1791 (1905).
6. AYERS, GILBERT H. Evaluation of Accuracy in Photometric Analysis. Anal. Chem., **21**:652 (1949).
7. WEST, PHILIP W. & COMPERE, MARIE. Colorimetric Determination of Copper in Water. Anal. Chem., **21**:628 (1949).
8. BILLS, C. E. ET AL. Reduction of Error in Flame Photometry. Anal. Chem., **21**:1076 (1949).
9. ROSSUM, J. R. Indirect Method for Estimation of Sodium in Water Supplies. Anal. Chem., **21**:190 (1949).
10. ———. Conductance Method for Checking Accuracy of Water Analyses. Anal. Chem., **21**:631 (1949).
11. LAMAR, WILLIAM L. Determination of Color of Turbid Waters. Anal. Chem., **21**:726 (1949).
12. TARAS, MICHAEL. New Indicator for Carbonate Alkalinity. Jour. A.W.W.A., **41**:527 (June 1949).

Editorial Note

Since information reached North America concerning the research of Biedermann and Schwarzenbach on hardness determinations, interest in the procedures has grown rapidly. Preliminary outlines of methods have been circulated and many laboratories have applied the methods to their local problems.

It seems appropriate to include in the JOURNAL, along with Connors' valuable resume of new methods, two somewhat parallel outlines of hardness testing methods, both of which are based upon the Schwarzenbach studies.

Because it appears likely that the *Standard Methods* Editorial Board will include a form of this procedure in the next edition, it is considered proper to publish Connors' review of the procedure and the work done by Diehl, Goetz and Hach, as well as that done by Betz and Noll. Diehl, Goetz and Hach submitted a brief paper for publication in November 1948 and a revised text in December 1949. Betz and Noll submitted their paper in August 1949. Both papers, in their original form, were sent to a number of laboratories for trial of the methods. From the two papers there should evolve a procedure suitable for publication in *Standard Methods*.

In connection with the use of the procedures, two studies appear to be indicated. First, there is a question whether or not the solutions related to the procedures should be kept in pyrex rather than in soft-glass bottles. Schwarzenbach indicates that soft glass is less desirable than pyrex. It also appears wise to check the buffers at intervals not less often than once every 30 days, particularly if the solutions are used daily. Definite information upon this point is needed.

Sources of Reagents

It is unfortunate that the introduction of these procedures into the American scene is being complicated by a competitive commercialized situation. The compound ethylenediaminetetraacetic acid, or disodium dihydrogen ethylenediaminetetraacetate dihydrate, is sold under the trade names Iminol D, Nullapon, Trilon B, Sequestrene NA 2, Versene and others.

At the time of publication, the following sources of reagents were known:

1. *Ethylenediaminetetraacetic acid* is available from Alrose Chemical Co., Providence, R.I.; from Bersworth Chemical Co., Framingham, Mass.; from W. H. & L. D. Betz, Philadelphia; from Organic Chemical Div., Eastman Kodak Co., Rochester, N.Y.; and from Hach Chemical Co., Ames, Iowa.

2. *Eriochrome black T* is available from W. H. & L. D. Betz, Philadelphia; from Calco Chemical Div., American Cyanamid Co., Bound Brook, N.J.; from E. I. duPont de Nemours & Co., Inc., Wilmington, Del., under the name "Pontachrome black TA"; from Geigy Co., Inc., New York; from General Dyestuff Corp., New York; and from Hach Chemical Co., Ames, Iowa.

There is reliable evidence that both materials are obtainable from other chemical manufacturers not presently listed with this office.

The Versenate Titration for Total Hardness

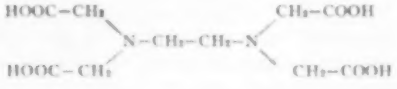
By Harvey Diehl, Charles A. Goetz and Clifford C. Hach

A contribution to the Journal by Harvey Diehl, Prof., Dept. of Chemistry, Iowa State College, Ames, Iowa; Charles A. Goetz, Prof., Dept. of Chemistry, Iowa State College, Ames, Iowa; and Clifford C. Hach, Pres., Hach Chemical Co., Ames, Iowa.

SCHWARZENBACH of the University of Zurich has reported in *Helvetica Chimica Acta* for 1947 and 1948 the results of a brilliant series of investigations of the complex ions of the alkaline-earth and other metals with aminopolycarboxylic acids. Iminotriacetic acid, ethylenediaminetetraacetic acid and other aminopolycarboxylic acids form very slightly ionized compounds with the alkaline earths, and the formation of these materials can be employed for the determination of calcium, magnesium and various bivalent metals. The problem of determining the endpoint in this titration was solved by Biedermann and Schwarzenbach (1) in an unusual manner, using a dye which also has the property of forming slightly ionized compounds with magnesium and calcium. For the determination of the total hardness of water (calcium plus magnesium) the method is superior to the soap method in accuracy and speed and is equal in accuracy to the time-consuming soda-reagent method.

Principle of Method

An alkaline solution of the organic acid:



(ethylenediaminetetraacetic acid), abbreviated H_4Ver, is marketed under the common name of "versene." This acid forms a series of salts on neutralization with sodium hydroxide, one of which, disodium dihydrogen versenate, $Na_2H_2Ver \cdot 2H_2O$, is used in the preparation of the standard solution for the titration of calcium and magnesium. The determination of total hardness is based upon the formation of stable, slightly ionized calcium and magnesium compounds:

$$Na_2H_2Ver + Ca^{++} = Na_2CaVer + 2\ H^+$$
$$Na_2H_2Ver + Mg^{++} = Na_2MgVer + 2\ H^+$$

The magnesium compound is somewhat more dissociated than the calcium compound. Schwarzenbach (2) has determined the constants for the formation of these undissociated calcium and magnesium compounds as 3.0×10^{10} and 5.0×10^{8} respectively.

The dye which is employed as indicator, Eriochrome black T, forms a soluble, undissociated, wine-red compound with magnesium. This compound is ionized to a greater extent than the magnesium versenate compound. Thus, during the titration the versenate first combines with the free calcium ions, next with the free magnesium ions, and finally, at the endpoint, extracts magnesium from the

magnesium-dye compound, changing the color from wine-red to blue.

Of the various hydroxylated, azo dyes that have the property of forming colored compounds with magnesium, the best for the purpose appears to be Eriochrome black T, also known as F241. F241 is a tribasic acid (abbreviated H_3In) which functions as an acid-base indicator with two color changes:

$$\underset{\text{wine-red}}{NaH_2In} \rightleftharpoons \underset{\text{blue}}{Na_2HIn} \rightleftharpoons \underset{\text{orange}}{Na_3In}$$

pH 6.3 pH 11.5

Of these three forms, only Na_3In forms un-ionized, colored compounds with the alkaline-earth metals:

$$Mg^{++} + Na_3In = NaMgIn + 2\ Na^+$$

The equilibrium constant for this reaction, $K = 10^7$, is so great that in the pH range 8 to 10 the blue form, Na_2HIn, is converted directly to the wine-red magnesium compound:

$$\underset{\text{blue}}{Mg^{++} + Na_2HIn} = \underset{\text{wine-red}}{NaMgIn} + H^+ + Na^+$$

On the addition of sodium versenate to such a solution, the magnesium is extracted from the compound, NaMgIn, and the color reverts sharply from wine-red to blue.

Although calcium forms a relatively weak, soluble, colored compound with Eriochrome black T, the compound is not sufficiently stable to serve as an indicator in the titration of calcium with sodium versenate. Since magnesium is required to function with the indicator, it is added to the sodium versenate solution before it is standardized. Thus, as the titration progresses, magnesium is introduced without requiring a blank correction.

A pH value of about 10 is best for the titration. Above this value, magnesium hydroxide may be precipitated, and at lower values the magnesium is not bound strongly enough to the dye to give the desired wine-red compound, NaMgIn. At higher pH values, also, the indicator shifts to its most alkaline (orange) form, so that at the endpoint a blue color is not obtained. Hydroxides and large amounts of carbonates which raise the pH above 10.5 interfere for this reason, but the bicarbonate ion and the carbonate ion, in themselves, as well as the ions of other weak acids, have no effect on the endpoint. A pH of 10 can be readily obtained and maintained by the addition of a sufficient amount of an ammonia–ammonium chloride buffer. At a pH of 10, the color change is sharp and may be approached rapidly, a great advantage over the soap titration. No boiling is required as in the soda reagent method and the titration can be carried out rapidly.

Biedermann and Schwarzenbach state that they were able to determine the total hardness of water with an accuracy within 2 ppm. The authors have confirmed this statement on waters with hardness ranging up to 1,400 ppm. The endpoint is sharp even with waters of extreme hardness, a situation in which the soap titration usually fails and a repetition of the soda reagent method with a smaller sample is necessary. The method is easily mastered by untrained operators and is applicable to mixtures of calcium and magnesium in any ratio. The water temperature, over the ranges normally encountered, has no effect on the titration.

As usual, pure calcium carbonate is used as the standard of reference, a standard solution being prepared by dissolving a weighed amount in hydro-

chloric acid and diluting to a definite volume. Using various volumes of standard calcium solution, the results obtained for the calcium carbonate titer of the standard sodium versenate solution are identical within one part in 500. The standard sodium versenate solution is sufficiently stable if prepared as described below.

One of the remarkable features of this titration is that it is not affected by considerable concentrations of salt. Thus, the authors have found that the titration is sharp and accurate in solutions containing up to 15 g. of sodium chloride per 100 ml. The utility of this fact in following the regeneration and washing of zeolite softening beds is obvious. Foams caused by detergents are without effect on the titration; some detergents used in the tests themselves contained calcium which was titrated. Water containing polyphosphates cannot be satisfactorily titrated for either total hardness or hardness in excess of the polyphosphate.

Interferences

The method was found to give satisfactory results on most waters, but in an occasional sample trouble was experienced with the endpoint. That copper was a source of difficulty was first pointed out to the authors by J. J. Connors, East Bay Municipal Utility Dist., Calif., who suggested the addition of sodium diethyldithiocarbamate, which removes the copper by precipitation. Studies of the effects of copper and certain other metal ions on the endpoint showed that the difficulties could be eliminated by the addition to the indicator of various materials which form complex ions or precipitates with the interfering metals.

Copper. The addition of diethyldithiocarbamate to the solution of the indicator effectively eliminates the interference of copper; this solution is designated as Indicator *B*. It is inadvisable to add diethyldithiocarbamate to the buffer solution, as it then reacts with any iron present to give an undesirable amount of brown color to the solution. Added after the buffer has been introduced and the iron precipitated as ferric hydroxide, the diethyldithiocarbamate is innocuous. For waters containing up to 5 ppm. of copper, then, the modified indicator (Alternate Procedure 1, below) is recommended. If more than 5 ppm. of copper is present, it is necessary to add sodium cyanide to complex the copper (Alternate Procedure 2, below).

Manganese. Manganese present as manganese dioxide or manganate causes the endpoint with Eriochrome black T to be rather indistinct. The reduction of these materials with hydroxylammonium chloride obviates this trouble. Again it is recommended that the reagent be added to the indicator. The mixture of Eriochrome black T and hydroxylammonium chloride, designated as Indicator *A*, can be used on waters containing up to 0.3 ppm. of copper. Any bivalent manganese present in the water titrates with the calcium and magnesium.

Iron. Interference by iron is encountered if the indicator is added before the buffer; the iron combines with the indicator to give a pink tinge to the blue color beyond the endpoint. When the buffer is added before the indicator, and Indicator *A* is used, iron in amounts up to 20 ppm. does not interfere. The buffer precipitates ferric hydroxide and any dissolved iron tends to be reduced by the hydroxylamine.

If iron is present in excess of 20 ppm., a faint tinge of pink may remain in the blue color at the endpoint and it is necessary then to add sodium cyanide (Alternate Procedure 2, below).

Aluminum. Aluminum in amounts exceeding 20 ppm. causes the endpoint to be indistinct. The addition of sodium tartrate eliminates this trouble.

Cobalt and nickel. Both cobalt and nickel interfere seriously with the endpoint. The only effective method of overcoming this trouble is the addition of sodium cyanide (Alternate Procedure 2).

Buffer

The ammonium hydroxide–ammonium chloride buffer recommended below has proved satisfactory. The amount of buffer added is not critical, an excess having no detrimental effect. Sodium hydroxide–sodium borate buffers and sodium hydroxide–sodium sulfide buffers, and mixtures of borate and sulfide buffers were tried and found objectionable, the endpoints being broad and indistinct. The amount of such buffers added is critical, an improper quantity giving pH values either too high or too low. Alkaline sulfides are oxidized by air and do not keep well. In addition, iron is precipitated by sulfide and the blue-black precipitate interferes with the endpoint. Inasmuch as iron is frequently present, a buffer containing sulfide is not recommended.

Reagents

The following reagents are used:

1. *Buffer solution.* Mix 67.5 g. of ammonium chloride with 570 ml. of concentrated ammonium hydroxide and dilute to about 1 l.

2. *Indicators*:

Indicator *A*—mix 0.5 g. of analytical reagent grade Eriochrome black T (F241) with 4.5 g. of hydroxylammonium chloride; dissolve 5 g. of this mixture in 100 ml. of alcohol.

Indicator *B*—mix 0.5 g. of analytical reagent grade Eriochrome black T (F241) with 4.5 g. of dry diethyldithiocarbamate; dissolve 5 g. of this mixture in 100 ml. of alcohol.

Indicator *C*—dissolve 0.50 g. of analytical reagent grade Eriochrome black T (F241) in 100 ml. of alcohol.

3. *Standard calcium chloride solution.* Dissolve 1.000 g. of pure calcium carbonate * in a little dilute hydrochloric acid. Dilute to exactly 1 l. and store in a glass-stoppered bottle; 1 ml. of this solution is equivalent to 1.000 mg. of calcium carbonate.

4. *Standard sodium versenate solution.* Dissolve 4.00 g. of analytical reagent grade disodium dihydrogen versenate and 0.1 g. magnesium chloride, $MgCl_2 \cdot 6H_2O$, in 750 ml. of water. Pipet out 25.0 ml. of the standard calcium chloride solution, add about 1.0 ml. of the buffer solution and four drops of the indicator. Titrate with the standard sodium versenate solution according to the procedure described below for the determination of hardness in water. The sodium versenate solution prepared as indicated above should be equivalent to more than 1.0 mg. of calcium carbonate per milliliter. Using the volume required for the titration and the total volume of the standard solution, calculate the volume to which the solution must be diluted to make it

* Calcium carbonate meeting the A.C.S. specification is not satisfactory as the tolerance for magnesium plus alkali metals is too high, 0.5 per cent. A more highly purified grade is required.

equivalent to 1.0 mg. of calcium carbonate per milliliter. Make the required dilution, mix well and restandardize.

Procedure for Total Hardness

For the determination of the total hardness of most waters, the following routine procedure should be employed. Occasionally interfering ions may be present (copper above 0.3 ppm. or large amounts of iron or manganese) which cause the endpoint to be indistinct; if so, Alternate Procedure 1 should be used. On the rare occasion when Alternate Procedure 1 fails to give a good endpoint (because of unusually large amounts of copper, iron or manganese) Alternate Procedure 2, which makes use of sodium cyanide to complex the various interfering metals, can be employed.

Routine Procedure

Pipet 50.0 ml. of the water sample into a 250-ml. flask. Add about 1 ml. of the buffer solution and mix by swirling. Add four drops of Indicator *A*. Titrate with the standard sodium versenate solution. At the endpoint, the solution should be clear and should change from wine-red to pure blue with no reddish tinge remaining. In daylight the color beyond the endpoint is sky blue, but under a tungsten filament lamp it is almost colorless.

Multiply the number of milliliters of standard sodium versenate solution by 20 to obtain the total hardness as parts per million of calcium carbonate. The magnesium added to the standard sodium versenate solution is accounted for in the standardization.

The accuracy of the determination is greatest when the volume of standard solution approaches the maximum volume which can be delivered by the buret. The volume of the sample may be adjusted to take advantage of this condition. Thus, for waters having a total hardness of less than 500 ppm., use a 100.0-ml. sample; for waters above 1,000 ppm., use a 25.0-ml. sample. The factor used in calculating the results must be changed accordingly: 100.0-ml. sample, multiply by 10; 50.0-ml. sample, multiply by 20; 25.0-ml. sample, multiply by 40. A small sample of a very hard water should be diluted to approximately 100 ml. with distilled water before adding the buffer; otherwise, magnesium hydroxide may be precipitated on addition of the buffer and erratic results obtained.

TABLE 1

Analysis of Limestone Samples

Limestone No.*	Al_2O_3	Fe_2O_3	MnO	P_2O_5	SiO_2	CaO	MgO	CO_2†
	per cent							
1,000	0.074	0.071	0.025	0.049	1.22	54.28	0.85	43.42
1,013	0.103	1.30	0.028	0.045	3.89	48.15	3.98	41.94
1,038	0.105	1.86	0.031	0.028	2.62	38.12	12.81	43.54

* Standard Sample Co., Ames, Iowa.
† Per cent CO_2 by difference.

Alternate Procedure 1

Pipet 50.0 ml. of the water sample into a 250-ml. flask. Add about 1 ml. of the buffer solution and swirl to mix the solution. Add four drops of Indicator *B* and four drops of Indicator *A*. Titrate with the standard sodium versenate solution. At the endpoint, the solution should be clear and should change from wine-red to clear blue or green. On the second titration, modify the size of the sample as discussed in the second paragraph under "Routine Procedure" above. Calculate the results as described therein.

The extra volume of buffer solution (5 ml. rather than 1 ml.) specified in this alternate procedure is necessary to offset the additional alkalinity resulting from the hydrolysis of the sodium cyanide added.

Discussion of Results

After checking the titration with known solutions of calcium and magnesium salts, separately and combined in various ratios, the method was tested on a number of hard waters. There is little point in checking the method against either the soap titration or the soda reagent method, both of which are relatively crude. In order to have a standard hard water which could be easily reproduced at some later time, standard limestone samples were dissolved and diluted accurately to a large known volume so that a convenient aliquot could be taken. The limestone samples used were analyzed carefully gravimetrically, two dehydrations of silica being made, the R_2O_3 being reprecipitated and the precipitates of both calcium and magnesium reprecipitated before the final ignition and weighing. Parallel analyses were made

TABLE 2

Analysis of Synthetic Hard Waters Prepared From Limestones

Limestone No.	Calculated Hardness as $CaCO_3$			Total Hardness Found by Sodium Versenate Titration
	Calcium	Magnesium	Total	
	ppm.			
1,000	969	21	990	987*
				990*
1,013	859	98	957	957
1,038	680	318	998	997

* Different analysts.

Alternate Procedure 2

Pipet 50.0 ml. of the water into a 250-ml. flask. Add about 5 ml. of the buffer solution and mix the solution by swirling. Add about 0.25 g. of sodium cyanide, mix well and add four drops of Indicator *A*. Titrate with standard sodium versenate solution. The endpoint color will change from wine-red to a pure blue. On the second titration, modify the size of the sample as discussed in the second paragraph under "Routine Procedure" above. Calculate the results as described therein.

on U.S. Bureau of Standards limestone samples. The results of the analyses on the limestones used are shown in Table 1. This general procedure is open to the possible criticism that hard waters inevitably contain some sulfate, which is not present in the dissolved limestone solutions. It has been shown, however, that sulfate has no effect on the titration, so that such criticism is not significant.

interfering ions. To aliquot samples of the waters were added various amounts of foreign materials, and their effects on the volume of sodium versenate solution and on the character of the endpoint were noted. The results have already been discussed in the sections dealing with interferences and buffers. A summary is given in Table 3 to show the amounts of foreign materials which can be tolerated. The

TABLE 3

Permissible Concentration of Interfering Ions

Material	Buffer and Indicator			
	NH_4OH-NH_4Cl Indicator *A*	NH_4OH-NH_4Cl Indicator *B*	$NH_4OH-NH_4Cl-NaCN$ Indicator *A*	$NH_4OH-NH_4Cl-NaS$ Indicator *A*
	ppm.			
Fe^{+++}	20	20	over 30	5
Al^{+++}	20	20	20	20
Cu^{++}	0.3	5	over 30	5
Mn^{++}	*	*	*	*
Mn as $KMnO_4$	20	2	20	20
Zn^{++}	*	*	*	*
Cd^{++}	*	*	*	*
Ni^{++}	fails	fails	over 20	fails
Co^{++}	fails	fails	over 20	fails
Cl^{-}	†	†	†	†
SO_4^{--}	†	†	†	†
PO_4^{---}	†	†	†	†

* No interference; titrates as hardness.
† No interference.

One-gram samples of these limestones were dissolved in hydrochloric acid and diluted to exactly 1 l. Aliquots of 25.0 ml. were then diluted and analyzed by the routine and alternate procedures given above. The results are shown in Table 2. The agreement between the calculated values and those found by the sodium versenate titration is quite satisfactory.

These synthetic waters were used in extensive studies of the effects of

great utility of cyanide in eliminating the interferences of all of the metals studied, with the exception of aluminum, is noteworthy.

Low-Hardness Waters

In extending the versenate titration to waters of very low hardness, little is gained by using a sodium versenate solution of lower strength, but the size of the sample may be greatly increased to advantage. In the follow-

ing procedure, a very large sample is taken and a preliminary titration is made to eliminate the effects of any calcium and magnesium in the buffer solution and to introduce into the solution sufficient magnesium to make the indicator function.

Procedure for low-hardness waters (less than 5 ppm.). In a 2-l. conical flask place about 50 ml. of distilled water and add about 5 ml. of standard calcium chloride solution. Add about 10 ml. of buffer solution and four drops of Indicator *A*. Titrate precisely to the endpoint with the standard sodium versenate solution. Add 500 ml. of the low-hardness water and an additional 1.5 ml. of Indicator *A*. Refill the buret and titrate again to the blue endpoint. Multiply the volume of sodium versenate used in the second titration by two to obtain the total hardness in parts per million of calcium carbonate.

Separate Calcium and Magnesium Determination

No good direct volumetric method for determining calcium in the presence of magnesium or magnesium in the presence of calcium is known at present. The versenate method can be coupled with the calcium oxalate separation to give fairly satisfactory values for calcium and magnesium separately. In the following procedure, calcium is precipitated as the oxalate, and the magnesium in the filtrate is determined by titration with sodium versenate. The calcium is then determined by subtracting the magnesium from the sum of calcium plus magnesium as determined by a second sodium versenate titration. Table 4 gives results obtained by the procedure on synthetic waters prepared by dissolving limestone as previously described.

Procedure for magnesium hardness. Prepare a buffer-oxalate solution as follows: to 35 g. of ammonium chloride and 1.5 g. of ammonium oxalate, $(NH)_4C_2O_4 \cdot H_2O$, add 3.5 ml. of ammonium hydroxide and sufficient water to make about 250 ml. The oxalate dissolves slowly; a little undissolved oxalate may be suspended by shaking before use and the suspension employed.

Pipet 100.0 ml. of the water into a 500-ml. conical flask. Also accurately pipet 25.0 ml. of the buffer-oxalate solution into the flask. The result will be to give the water a pH value of 7.5–8 and cause the calcium to precipitate as the oxalate. Shake well and filter

TABLE 4

Separate Calcium and Magnesium Determination

Sample No.	Magnesium		Calcium		Total Hardness	
	Present	Found	Present	Found	Present	Found
	ppm. as $CaCO_3$					
1	21	20	969	964	990	984
2	543	541	537	538	1,080	1,079
3	673	677	333	330	1,006	1,007
4	338	337	667	668	1,005	1,005

through a double, dry filter paper of fine texture, for example Whatman No. 42. Receive the filtrate in a dry beaker. Pipet 50.0 ml. of the filtrate into a 250-ml. conical flask, add about 10 ml. of the regular buffer solution and proceed as in the usual titration for hardness.

Multiply the number of milliliters of standard sodium versenate solution used by 25 (not 20, because of the dilution of the sample by the buffer-oxalate solution) to obtain the magnesium as an equivalent amount of calcium carbonate in parts per million. Subtract this value from the total hardness to obtain the calcium hardness.

If the total hardness is greater than 800 ppm., it is advisable to use only 50.0 ml. of the water and then add 50.0 ml. of distilled water and 25.0 ml. of the buffer-oxalate solution. A factor of 50 is then used in calculating the magnesium hardness.

Summary

A rapid and accurate determination of the total hardness of water can be made by titrating the water with sodium versenate (the disodium salt of ethylenediaminetetraacetic acid). At a pH of 10, calcium and magnesium form negligibly ionized compounds with sodium versenate. The endpoint is found by the addition of a blue dye (F241) which also forms an undissociated, wine-red compound with magnesium but from which the magnesium is extracted by an excess of sodium versenate. The titration can be applied to waters ranging from very low to very high hardness. Large concentrations of salts do not interfere and temperature has little effect. Copper, iron and certain other bivalent metals interfere with the endpoint, but their effects can be eliminated by the addition of various complexing agents, which are conveniently added with the indicator. The method has been adequately tested and is suitable for use by untrained operators. With slight modification the method can be applied to the analysis of water of very low hardness.

The method may be combined with the oxalate separation of calcium to give a rapid method for the separate determination of calcium and magnesium hardness.

Acknowledgment

The authors wish to express their appreciation for the cooperation received from the American Water Works Association and its various members who have tested the method since its submission in November 1948.

References

1. Biedermann, W. & Schwarzenbach, G. Complexons XI. The Complexometric Titration of Alkaline Earths and Some Other Metals With Eriochrome Black T. Chimia, **2**:56 (1948).
2. Schwarzenbach, G. & Ackermann, H. Complexons XII. Homologs of Ethylenediaminetetraacetic Acid and Their Alkaline-Earth Complexes. Helv. Chim. Acta, **31**:1029 (1948).

Total-Hardness Determination by Direct Colorimetric Titration

By J. D. Betz and C. A. Noll

A contribution to the Journal by J. D. Betz, Asst. Gen. Mgr., and C. A. Noll, Chem. Engr., W. H. & L. D. Betz, Philadelphia.

THE total hardness of water is most commonly determined by the soap method described in *Standard Methods* (1). The soap method, however, is subject to certain interferences which produce inaccurate results. In addition, unless careful technique is employed by the operator, results may be considerably in error. Despite these disadvantages, the relative simplicity of the soap method in comparison with others explains its widespread use.

The method of hardness determination described in this paper is more accurate than the soap method and is considerably more rapid. A sharp color change indicates the endpoint, and the ions commonly present in water do not interfere with the test. Hardness values up to 1,200 ppm. can be titrated without dilution of the sample and are accurate within approximately 2 per cent. Higher hardness values can also be determined without dilution of the sample by using a stronger titrating solution. With a larger sample and a microburet, hardness in the range of 0.0–2.0 ppm. can be determined within 0.1 ppm.

The method is based on the titration of a water sample with an organic sequestering agent which will form unionized complexes with calcium and magnesium. The titration is performed in the presence of an indicator which is red when there are calcium and magnesium ions and blue in their absence. A buffer solution is added prior to the titration to adjust the pH value of the sample to about 10.0.

Theory of Test

The action of organic sequestering agents such as the amino polycarboxylic acids in forming complexes with the alkaline-earth metals has been described (2, 3). Ethylenediaminetetraacetic acid and its sodium salts have been found effective in sequestering magnesium and, especially, calcium ions. In such a complex with calcium, the calcium is bonded by two ionic and two coordinate linkages, known as a chelate ring. When sufficient chelating agent, such as ethylenediaminetetraacetate, is added to a solution containing calcium ions, the calcium is firmly bonded in an un-ionized soluble complex and no calcium ions remain in solution. This phenomenon has been employed in the determination of the alkaline-earth metals by using as a color indicator a dye which exhibits one color in the presence of alkaline-earth metal ions and another color in their absence.

Eriochrome black T, the dye employed as an indicator in this work, exhibits, at a pH of 8–10, a red color in the presence of calcium and magnesium ions and a blue color when these ions have been sequestered by the ethylenediaminetetraacetate. The complexes formed in the alkaline pH range are particularly stable. In the determination of total hardness in water, this

principle was employed first by Biedermann and Schwarzenbach.

In the method described by Biedermann and Schwarzenbach, a non-alcoholic dye indicator solution was employed with an ammonium chloride–ammonium hydroxide buffer. It was stated that a sharp color change could not be obtained with calcium alone, but magnesium, if absent, must be deliberately introduced into the solution to obtain the endpoint. With the use of revised indicator, buffer and titrating solutions, the authors have found that the color change at the endpoint is improved considerably. In addition, the color change in pure calcium solutions has been found to be quite sharp and accurate—definitely superior to the endpoint for pure magnesium solutions with the use of reagents of available purity. A disadvantage of the method used by Biedermann and Schwarzenbach is that very small quantities of copper and manganese interfere with the test and no endpoint can be obtained. As little as 0.1 ppm. copper prevents an endpoint. With Philadelphia city water, the amount of copper introduced by even a few feet of travel through copper piping was sufficient to prevent any endpoint in this test.

Investigation by the authors of various thio- organic salts and mercaptans failed to remove this interference when both copper and iron were simultaneously present in solution. By altering the composition of the buffer and incorporating sodium sulfide, however, this interference was eliminated. The simultaneous presence of copper, iron and manganese will not interfere in the test with this revised buffer solution.

Preparation of Reagents

Hardness buffer solution. Solution 1—dissolve 40 g. of cp. sodium tetraborate ($Na_2B_4O_7 \cdot 10H_2O$) in approximately 800 ml. of distilled water.

Solution 2—dissolve 10 g. cp. sodium hydroxide and 5 g. cp. sodium sulfide in 100 ml. distilled water. When cool, mix the two solutions and make up to 1.0 l. with distilled water.

The buffer solution should be kept stoppered when not in use.

Hardness titrating solution. Dissolve 4.0 g. of disodium ethylenediaminetetraacetate dihydrate in approximately 800 ml. of distilled water. Add 0.86 g. of cp. sodium hydroxide. Adjust against standard calcium chloride solution so that 1 ml. equals 1 mg. as $CaCO_3$.

Hardness indicator solution. To 30 ml. of distilled water, add 1.0 ml. of 1.0 *N* sodium carbonate solution. Add 1.0 g. of Eriochrome black T and mix. Make up to 100 ml. with 99 per cent isopropanol.

Test Procedure

Measure 50 ml. of the sample and transfer to a white porcelain casserole or evaporating dish. Add 0.5 ml. of buffer solution and stir. Add four to six drops of indicator solution and stir. If hardness is present, the sample will turn red.

Add the titrating solution slowly from the buret with continued stirring. The endpoint is reached when the color changes from red to blue.

When approaching the endpoint, the sample begins to show some blue coloration, but a definite reddish tinge can still be observed. The endpoint is the final discharge of this reddish tinge. The addition of more titrating solution will not show any further color change.

In the above procedure, the titrating solution must be added slowly, since the endpoint is sharp and rapid. For routine hardness determination, it is suggested that 50 ml. of the sample

be measured, but only approximately 40–45 ml. should be added to the casserole at the start of the test. Add the buffer and indicator as described above and rapidly titrate to the endpoint. Then add the remaining portion of the sample. The hardness present in this remainder of the sample will turn the contents of the casserole red again. Continue to titrate slowly until the final endpoint is reached.

Results of Test

The results of the test can be calculated in accordance with the formula:

TABLE 1

Hardness Values for Pure Calcium and Magnesium Solutions

Calcium Present	Hardness Found	Magnesium Present	Hardness Found
ppm. as $CaCO_3$			
0	0	0	0
4	5	4	6
8	8	8	9
12	12	12	13
20	22	20	20
50	50	50	50
100	100	100	100
200	200	200	196
500	498	500	480

$$\text{ppm. Hardness as } CaCO_3 = \frac{\text{ml. Titrating solution} \times 1{,}000}{\text{ml. Sample}}$$

Using a 50-ml. sample, the hardness in parts per million as $CaCO_3$ is equal to the number of milliliters of titrating solution required multiplied by 20.

Table 1 illustrates the data obtained using this direct titration method on pure calcium and magnesium solutions of varying hardness content. As can be observed, with calcium solutions up to 500 ppm. hardness, quite accurate results were obtained and the endpoint was quite sharp. Similar accuracy was obtained on pure magnesium solutions, except for the 500-ppm. value. At high magnesium concentrations, the alkalinity introduced by the buffer solution causes precipitation of magnesium hydroxide.

Table 2, which illustrates the effect of various ratios of calcium and magnesium, indicates that the relative concentrations of these two ions are immaterial in the test. In general, it has been found that, in the range of 100 ppm. hardness, the titration can yield hardness values within 2 ppm. of the gravimetric standard with no unusual precautions on the part of the operator.

TABLE 2

Effect of Calcium-Magnesium Ratios

Present in Solution			Total Hardness Found
Mg	Ca	Total Hardness	
ppm. as $CaCO_3$			
0	100	100	100
2	98	100	100
4	96	100	102
6	94	100	100
8	92	100	102
10	90	100	100
20	80	100	102
40	60	100	100
50	50	100	100
60	40	100	100
80	20	100	98
90	10	100	100
92	8	100	102
94	6	100	100
96	4	100	102
98	2	100	100
100	0	100	100

Table 3 demonstrates that high hardness values can be titrated without dilution of the sample. Using the standard-strength titrating solution (1 ml. equals 1 mg. $CaCO_3$), approximately 1,200 ppm. hardness is the highest value that should be titrated without dilution of

the sample. Above this figure the endpoint is not sharp because of the large volume of titrating solution (60 ml.) which has been added. By using titrating solutions of higher strength, hardness values of 2,000 ppm. can be accurately determined without dilution of the sample. With the use of the soap method, a hardness of approximately 140 ppm. is the upper limit which can be tolerated without dilution, according to *Standard Methods*.

TABLE 3

Effect of High Hardness Without Dilution

Hardness* Present	Titrating Solution—1 ml. equals:		
	1 mg. $CaCO_3$	5 mg. $CaCO_3$	10 mg. $CaCO_3$
	ppm. as $CaCO_3$		
200	196	200	200
1,000	1,000	1,000	990
1,100	1,092	1,092	1,100
1,200	1,216	1,200	1,200
1,400		1,400	1,400
1,600		1,610	1,600
1,800		1,800	1,800
2,000		2,000	2,000

* 80 per cent calcium, 20 per cent magnesium.

Ionic Interference

Interfering ions were investigated as shown by the data in Table 4. The values indicate the maximum concentrations of possible interfering ions investigated. It is probable, however, that concentrations higher than those shown by Table 4 can be tolerated without interference.

No interference with test results was obtained with the use of polyphosphate concentrations of 25 ppm., although slightly low hardness results were found at a polyphosphate concentration of 50 ppm. The simultaneous presence of 2.5 ppm. iron as Fe and 10 ppm. polyphosphate gave no interference. Sodium hydroxide concentrations in excess of 300 ppm. as NaOH created difficulty in the endpoint. Dilution of the sample is recommended where the sodium hydroxide concentration exceeds 300 ppm. No interference resulted from the presence of 1.0 ppm. manganese as Mn. Higher concentrations of manganese did not interfere with the endpoint using the recommended buffer solution, but added to the indicated hardness as shown by Table 5. Of course, such high manganese concentrations are unusual.

TABLE 4

Freedom From Ionic Interference

Ion	Amount Employed Without Interference *ppm.*
Copper (Cu^{++})	10
Iron (Fe^{+++})	20
Iron (Fe^{++})	20
Zinc (Zn^{++})	10
Lead (Pb^{++})	10
Tin (Sn^{++})	10
Tin (Sn^{+++})	10
Aluminum (Al^{+++})	10
Chloride (Cl^{-})	10,000
Sulfate (SO_4^{--})	10,000
Sulfite (SO_3^{--})	500
Chromate (CrO_4^{--})	500
Phosphate (PO_4^{---})	100
Nitrite (NO_2^{-})	500
Nitrate (NO_3^{-})	500
Carbonate (CO_3^{--})	1,000
Silicate (SiO_2^{--})	200
Free mineral acid (HCl)	100
Quebracho tannin	200

The temperature of the sample has been determined to have no effect on the accuracy of the test in the range of 10°–40°C., although the endpoint was sluggish at 10°C.

A definite advantage of this direct titration method is that the effect of interfering ions can be eliminated by dilution of the sample. Usually interference is eliminated by taking a smaller sample, such as 25 ml., and

TABLE 5

Manganese Interference

Present		Found	
Hardness* as $CaCO_3$	Manganese as Mn	Hardness as $CaCO_3$	Endpoint
ppm.			
100	0.0	100	sharp
100	1.0	100	sharp
100	2.0	102	sharp
100	3.0	106	sharp
100	10.0	112	sharp

* 80 per cent calcium, 20 per cent magnesium.

example, the presence of chromate imparts a yellow color to a sample, so that the blue color at the endpoint is shown as green. The true endpoint in each test is taken as the disappearance of the reddish tinge of the sample, regardless of the final color developed in the presence of certain ions.

Table 6 is a comparison between gravimetric determinations of hardness on various waters and the direct titration method. Soap hardness values are also included. Most of the investigation of the direct titration method was conducted on pure calcium and magnesium solutions, gravimetrically standardized, so that this check was made on several typical waters. As can be observed from Table 6, close agreement was shown between the gravimetric and direct titration values.

TABLE 6

Gravimetric Check on Various Waters

	Raw Water		Boiler Feedwater		Boiler Water	
	ppm.					
Calcium as $CaCO_3$ (gravimetric)	196	80	29	12.5	0	0
Magnesium as $CaCO_3$ (gravimetric)	54	38	16	7.5	0	6
Total hardness as $CaCO_3$						
Gravimetric	250	118	45	20	0	6
Soap	216	100	48	20	0	0
Titration	254	118	44	20	0	5
Alkalinity as $CaCO_3$						
Phenolphthalein	8	0	0	0	376	132
Methyl orange	96	68	36	40	448	184
Sulfate as SO_4	80	72	36	12	480	560
Chloride as Cl	95	35	9	4	104	132
Phosphate as PO_4					40	0
Nitrate as NO_3	2.0	25	0.8	1.4	45	8
Iron as Fe	0.2	0.1	0.1	0.1	0.2	1.8
Color	7	9	3	5	55	125
pH	8.3	8.1	7.4	7.0	11.3	10.3

diluting to 50 ml. with distilled water. If interfering ions are expected, it is best to standardize on the use of a diluted sample.

Although the ionic concentrations shown in Table 4 did not interfere with the test and the correct total hardness values were shown in their presence, the color change of the endpoint was not always from red to blue. For

Low Hardness Values

In the control of zeolite softeners, it is frequently desirable to measure

TABLE 7
Determination of Low Hardness

Present	Found		
	Operator A	Operator B	Operator C
Hardness* as $CaCO_3$—*ppm.*			
0.0	0.0	0.0	0.0
0.3	0.3	0.3	0.3
0.5	0.4	0.4	0.5
0.8	0.8	0.8	0.8
1.0	0.9	0.9	0.9
1.2	1.2	1.3	1.2
1.4	1.4	1.4	1.4
1.6	1.6	1.6	1.6
1.8	1.8	1.8	1.7
2.0	2.0	2.0	2.0

* 80 per cent calcium, 20 per cent magnesium.

the hardness of the softener effluent quite accurately, particularly when it is used as makeup water for high-pressure boilers. The soap method is not sufficiently sensitive to indicate small hardness concentrations in the softener effluent. By some modification of the direct titration method, however, it is possible to determine with a high degree of accuracy the hardness content of such waters.

Table 7 gives the values obtained over a range of 0.0–2.0 ppm. hardness. Results are shown for three operators who were unaware of the hardness content of the water samples to be tested. It will be noted that the deviation from the correct value never exceeded 0.1 ppm. In the determination of such low hardness values, a larger-size sample (100 ml.) is employed, with 1.0 ml. of buffer solution and seven to nine drops of indicator solution. For best observation of the endpoint, it is recommended that an incandescent light source be used for illumination of the sample during titration. The titrating solution is added very slowly, with vigorous stirring, from a microburet, and it is necessary that the operator possess proper technique in its use.

Hardness and Soap Destruction

It should be noted that the total-hardness values secured by the direct titration method represent the sum of the calcium and magnesium ions present. The total hardness determined by titration will check with the value calculated from the gravimetric determination of calcium and magnesium, but will not necessarily coincide with the soap hardness value. The soap method is really a measurement of the soap-destroying properties of a water and not necessarily a true measure of the calcium and magnesium content.

Determination of Calcium and Magnesium

Frequently it is desirable to separate total hardness into the individual calcium and magnesium ions. Since the direct colorimetric titration accurately measures the total calcium and magnesium content, if either ion is determined singly, the concentration of the remaining ion can be found by subtraction from the total hardness value.

Direct Calcium Titration

Schwarzenbach, Biedermann and Bangerter (4) mentioned the use of a saturated solution of ammonium purpurate as an indicator for calcium. Studies by the authors have revealed that water solutions of this dye are not stable even for 24 hours because of oxidation of the indicator. Alteration of the indicator pH value to the acid range extended stability only to three days. The use of alcohols, glycols and oils as solvents and dispersants failed to overcome the instability of the indicator. Consequently, the dry indicator was dispersed in various dry mixtures.

Sodium chloride was found best for this purpose and the dye-chloride mixture was ground to the desired degree of fineness for dispensing with a calibrated dipper. In this dry form, the indicator is stable.

The direct colorimetric titration of calcium is based on titration of the sample with the same sequestering agent used in the total-hardness test, in the presence of an indicator sensitive to calcium ions and insensitive to magnesium ions under the test conditions. The endpoint, which occurs when all the calcium ions are sequestered, is a color change from salmon-pink to orchid-purple.

Reagents Employed

The following reagents are used:

Sodium hydroxide—1.0 *N* solution.

Hardness titrating solution—the same as for the total-hardness test.

Calcium indicator—mix well 0.20 g. ammonium purpurate with 100 g. of cp. sodium chloride. Grind the mixture to 40–50 mesh.

Test Procedure

Measure 50 ml. of the sample and transfer to a casserole. Add 2 ml. of 1.0 *N* sodium hydroxide to the sample and stir. Add 0.20 g. of calcium indicator and stir (a calibrated dipper is sufficiently accurate for this purpose). If calcium is present, the sample will turn salmon-pink.

Add the titrating solution slowly from the buret, with continued stirring. When approaching the endpoint, the sample begins to show a purple tinge. The endpoint is a final change to orchid-purple. Once the endpoint is reached, additional titrating solution will not produce any further color change. The endpoint should always be checked by adding one additional drop of titrating solution and observing whether any further color change occurs.

Results

Results may be calculated thus:

$$\text{ppm. Calcium as } CaCO_3 = \frac{\text{ml. Titrating solution} \times 1{,}000}{\text{ml. sample}}$$

Using a 50 ml. sample, the calcium in parts per million as $CaCO_3$ is equal to the number of milliliters of titrating solution required multiplied by 20.

The relative concentrations of calcium and magnesium were investigated in a manner similar to that used for the data in Table 2 and found not to affect the accuracy of the calcium titration. Calcium values as high as 1,200 ppm. were titrated without dilution of the sample. Test accuracy was approximately 2 per cent of gravimetric over the range of 100–1,200 ppm. $CaCO_3$. In the low range of 0–5 ppm. $CaCO_3$, the test accuracy is within 1–2 ppm.

The following concentrations of ions were investigated without interference: copper, 2 ppm.; ferrous iron, 20 ppm.; ferric iron, 20 ppm.; manganese, 10 ppm.; zinc, 5 ppm.; lead, 5 ppm.; aluminum, 5 ppm.; tin, 5 ppm.; sulfate, 10,000 ppm.; chromate, 500 ppm.; silicate, 100 ppm.; carbonate, 50 ppm.; bicarbonate, 500 ppm.; nitrate, 500 ppm.; nitrite, 500 ppm.; polyphosphate, 100 ppm.; sulfite, 500 ppm.; ammonia as N, 2,000 ppm.; chlorine, 2 ppm.; bromine, 2 ppm.; free mineral acid (H_2SO_4), 100 ppm.; and Quebracho tannin, 50 ppm. Orthophosphate will precipitate calcium at the pH of the test. Gravimetric checks on various waters, similar to those for Table 6, have confirmed the accuracy of the direct calcium titration.

Like the direct colorimetric titration of total hardness, the direct colorimetric calcium titration is more accurate than

the soap method and is considerably more rapid. The method is subject to little interference, and, where present, this interference can be overcome by dilution of the sample. The method has been tested in routine calcium determinations on approximately 1,500 samples. Because of the accuracy of both the calcium and total-hardness methods, an accurate magnesium value is obtained by subtraction.

Alternate Method for Magnesium

Since the direct colorimetric titration for total hardness measures the total calcium and magnesium content, magnesium can be determined by precipitating calcium from the sample with ammonium oxalate and determining the remaining hardness, which is then due to magnesium only. This method is not as rapid or convenient as the direct colorimetric titration of calcium and is more subject to errors of technique.

Test Procedure

Measure 75 ml. of the sample into a beaker or similar vessel. Add 1 ml. of hardness buffer solution. Add 1 ml. of 5 per cent ammonium oxalate. Mix and allow to stand for five to ten minutes. Filter through Whatman No. 5 filter paper. Discard the first 5–10 ml. of the filtrate.

Measure 50 ml. of the filtrate and tranfer to a casserole. Add four to six drops of hardness indicator. Proceed with the titration as in the direct colorimetric total-hardness titration.

Conclusions

The total-hardness method of Biedermann and Schwarzenbach has been revised to improve the sharpness of the endpoint and to overcome the effects of minute quantities of copper and manganese in preventing an endpoint. With the revised buffer, indicator and titrating solutions, the effects of interfering ions have been determined. The method is subject to little interference, which, when present, can be overcome by dilution of the sample.

The direct colorimetric titration for total hardness is much more rapid than the soap method and less subject to errors of technique. Hardness values up to 1,200 ppm. can be titrated with the standard-strength titrating solution without dilution of the sample and with an accuracy within approximately 2 per cent of the gravimetric value.

The method is extremely sensitive in the determination of low hardness values and an accuracy within 0.1 ppm. is possible for 0.0–2.0 ppm. hardness.

The method has been tested in routine hardness determinations on approximately 18,000 water samples over a six-month period.

A direct colorimetric titration has been developed for the determination of calcium in the presence of magnesium, using the same titrating solution as for total hardness.

References

1. *Standard Methods for the Examination of Water and Sewage.* A.P.H.A. & A.W.W.A., New York (9th ed., 1946).
2. Schwarzenbach, G. & Ackermann, H. Complexons V. Ethylenediaminetetraacetic Acid. Helv. Chim. Acta, **30**: 1798 (1947).
3. Biedermann, W. & Schwarzenbach, G. The Complexometric Titration of Alkaline Earths and Some Other Metals With Eriochrome Black T. Chimia, **2**: 56 (1948).
4. Schwarzenbach, G.; Biedermann, W. & Bangerter, F. Complexons VI. New Simple Titrating Methods for Determining the Hardness of Water. Helv. Chim. Acta, **29**:811 (1946).

Possibilities of Newer Bacteriological Techniques

By Harry G. Neumann

A paper presented on Oct. 27, 1949, at the California Section Meeting, Sacramento, Calif., by Harry G. Neumann, Research Microbiologist, San. Eng. Div., Dept. of Water & Power, Los Angeles.

SINCE the application of the coliform test to determine the sanitary quality of waters on this continent, there have been numerous attempts to improve analytical methods based upon the routine use of coliform organisms as an index of such quality. During the half century which has passed, a considerable amount of effort was expended in attempts to standardize results so that data from various sources would be reasonably comparable. The development of such methods has proved invaluable in the interpretation of results for most waters.

It appears, however, that reliance on these methods alone has resulted in a reduction of interest in the exploration of new fields and the fundamental re-examination of old fields which is so necessary for the development of new techniques and the improvement of present tests. Changes in procedure have been effected and research has been conducted on the general utility of new methods by workers in the field of water purification and sanitation. Nevertheless, experience indicates that it is necessary to investigate recent developments in other microbiological fields, since in the past they have contributed potential methods and valuable data. The importance of recently acquired information is indicated in the portion of this paper devoted specifically to newer techniques believed worthy of consideration in connection with methods used to determine the safety of water.

The coliform test has evolved from the original plating procedure, with or without preliminary enrichment in glucose broth and identification of coliform organisms, to the present enrichment in the more selective standard lactose media followed by a number of confirmatory methods. In the course of this development many techniques were found wanting. Attitudes were created from failures, resulting in reversion to the lengthy completed test which proved impractical for routine control work, especially when numerous samples were to be examined. Recently this shortcoming has been alleviated in part by the more flexible procedures of the present *Standard Methods* recommendations. Since present routine and special procedures are fully described in *Standard Methods*, no attempt will be made to consider them in detail here.

Despite attempts to improve procedures, the only reduction of time in routine examination has been effected through the use of lauryl sulfate tryptose broth with brilliant green bile confirmation. This medium may be used only on proved correlation of results with standard lactose broth when no reduction in coliform density is evident. Therefore, lactose broth has not as yet been entirely supplanted as an enrichment medium. Recent studies

have shown that lauryl sulfate tryptose broth produced about 16 per cent fewer false positives than lactose broth and was also superior in the detection of coliform organisms in most comparisons made with various waters (1). Recommendations that it replace lactose broth are made with the reservation that further studies should be carried out using waters of high quality from other areas. Some media have been suggested to replace lactose broth, not necessarily to reduce procedure time but to eliminate problems produced by interfering organisms. In general, the use of media such as EC broth and Eijkman broth, employing incubation temperatures near 44°C., might be acceptable if the criterion for polluted water were based upon *Esch. coli* rather than the coliform group. Unpublished data from investigations conducted by the Sanitary Engineering Div. of the Los Angeles Dept. of Water and Power indicate that, while some interfering bacteria and most intermediate coliform organisms are eliminated, there is some repression of *Esch. coli* with Eijkman broth.

Although it has been accepted that the present coliform method is the best routine procedure yet devised, it yields only rough estimates of coliform density. It is beyond the scope of this paper to discuss all of the shortcomings of present techniques, or any of them in detail, but several should be noted. In addition to imperfections mentioned at other points in the discussion are those arising from the production of positive presumptive results by noncoliform bacteria and those of questionable sanitary significance and doubtful enteric origin.

Technical Problems

A general problem which must be considered in the application of new techniques to methods based upon isolation of an organism or group of organisms arises in determining the type of selective properties required. A question of major importance is posed by the use of any antibacterial agents proposed or previously developed, since sanitarians differ in their views on the limits of the coliform group. Some believe it is too inclusive, for an excessive incidence of these organisms is often found in waters known to be of good quality. The opinion has also been expressed that the coliform group is not inclusive enough, as slow-lactose-fermenters often have been demonstrated in fecal material. Some aberrant coliform organisms are believed to be associated with gastroenteric disturbances, while other atypical or attenuated forms occur which are considered to represent remote pollution no longer of sanitary significance.

The validity of classifying bacteria of fecal and nonfecal origin within the coliform group also is questionable. There is considerable evidence that tests for this type of differentiation are not practical.

It will become evident in the discussion of techniques which offer possibilities for application to the determination of sanitary quality that two outstanding problems exist. The first is occasioned by the repression of coliform organisms by antibacterials used in inhibitory media. Most experimentation with new agents resolves itself into a question of whether antibacterials can be incorporated into a medium in such concentration as to prevent the growth of undesired organisms while allowing full development of the coliform group. The second difficulty is that the variation in waters offers a formidable impediment to the realization of an *ideal* presumptive medium since complexity

of inhibition is increased and standardization is made difficult.

The problems inherent in differentiation which are related to sensitivity and selectivity make isolation extremely difficult to accomplish by any means adaptable to routine practice. The principal factor, of course, is the range of organisms which are considered significant in the determination of sanitary quality. Limits are not too sharply defined in most groups within the Enterobacteriaceae, but there is a continuum of closely related types which differ somewhat in their biochemical activities. Although determination of the significance of organisms closely related to the coliform group awaits further research, attempts should be made to improve techniques based upon the present standard coliform method.

One problem arises indirectly in establishing the manner in which new techniques should be evaluated. The soundest method of determining the efficacy of agents employed in certain procedures consists in utilizing parallel studies under conditions of actual testing—that is, routine samples containing a characteristic mixed microflora should be used for comparative studies. Although exploratory problems may be solved by pure culture studies, too great reliance must not be placed on them.

Consideration of these factors is necessary in order that agencies concerned with water purification and sanitation can direct an effective attack on the development of better and more economical means of testing water.

Requirements of Newer Techniques

Before discussing recently acquired knowledge which might lend itself to the development of newer bacteriological techniques, the general requirements of such methods should be considered.

It is recognized that the greatest need in the field of primary requirements is for a more rapid and generally applicable *presumptive* test. It is at this stage that undesired organisms can best be eliminated. Lactose broth as an initial medium has several inadequacies, as indicated by the occurrence of both false positive and false negative results with many waters. This interference is largely responsible for increased operational costs and expenditure of effort which could be used for effecting better sanitary control. At present there is a trend toward demanding greater frequency of routine examination and the use of special methods to accomplish this end. In routine practice, the development of too great precision in methods that show promise of facilitating testing is not necessary. Since it is evident that present methods produce results which may better be described as estimations, there should be no objection to new techniques which may prove practicable without appreciably reducing accuracy. Emphasis has been placed upon experimentation on the initial medium because of the opportunities offered for bacterial selection and inhibition there.

The requirements of the techniques themselves should be such that results are reasonably uniform with most waters, so that the significance of the findings will not vary too widely. This objective is difficult to attain since the microflora of waters differ extensively. Time, skill, labor and material should be minimal so that results may be obtained rapidly and at reasonable cost. In order to avoid the effect of speculation on the character of the results, the procedures should require a minimum of judgment by the technician. Accuracy should be such as to distinguish between safe and unsafe waters. As previously noted, greater precision can

be secured by multiple examination or by the use of special methods.

Recent Techniques and Devices

1. *Antibiotics.* The widespread use of the "wonder drug," penicillin, especially in World War II, has given impetus to extensive research into one of the newest fields of importance in microbiology, that concerned with the general application of antibiotic agents. Although these substances are more often thought of as exercising a bacteriostatic effect upon pathogens, their selective action has also been utilized for separating bacteria from one another.

There have been numerous reports of the effective use of antibiotics in the isolation of certain organisms from mixed cultures. Actinomycin was used to separate Gram-negative from Gram-positive bacteria (2). Tyrothricin was shown to allow the isolation of Gram-negative bacteria even in the presence of overgrowth by Gram-positive cocci (3). One point of special interest to those concerned with the possibility of newer techniques in the bacteriology of water was found in the course of studies with penicillin. Although it was noted that this antibiotic possessed marked bacteriostatic and bactericidal properties for some of the common pathogenic bacteria, largely the Gram-positive cocci, *organisms belonging to the coliform-typhoid-dysentery group were not affected* (4). In general, most Gram-positive bacteria are more sensitive to the action of the majority of antibiotics than are the Gram-negative forms (5). This fact suggests the use of these agents to eliminate Gram-positive organisms largely responsible for interference in the initial stages of the coliform test.

Although comparatively little is yet known about the mode of action of these agents, it has been shown that some antibiotics, especially penicillin, exert a strong selective action in relatively low concentration against many types of bacterial cells without acting as a general protoplasmic poison. Their action is more subtle, accomplishing bacteriostasis by interference with specific individual reactions rather than by interruption of cellular metabolism as a whole (6). This distinction between antibiotics and the classical antiseptics is important in indicating the potential usefulness of these agents. It is apparent that antibiotics could be applied to the problem of bacterial separation with a minimal probability of repression of the organisms being isolated.

Samples employed in the routine bacteriological testing of water normally contain mixed microflora. It is likely that some of the attendant problems such as false negatives resulting from competition with index organisms might be eliminated or materially reduced if proper antibiotics could be found.

Although there have been few reports of specific attempts to apply antibiotics to the development of newer techniques, some research is currently in progress. Recently penicillin, tyrothricin and streptomycin were considered as substances which might be of value in the elimination of *false negative* reactions when incorporated into the lactose broth presumptive medium. The use of antibiotics suggests a new approach in the search for a more desirable initial medium, for both penicillin and tyrothricin have already proved valuable as inhibitory agents in selective media.

Results of such studies conducted at the University of Southern California, using samples from the Los Angeles distribution system, indicated, however,

that the media used offered no advantage over the standard lactose broth as a presumptive medium. The three antibiotics noted above were incorporated into standard lactose broth in several concentrations. It was concluded that modifications in the formulation of the antibiotic media employed must be made for them to be of practical value in water analysis.*

Retaining the principle of using an antibiotic as a selective agent, the most obvious change was in the concentration of the agent. It was concluded that streptomycin would be of no value in the problem at hand, since determinations of antibiotic sensitivity indicated that coliform and noncoliform organisms had approximately the same sensitivity to this substance (7).

Although there is considerable evidence suggesting that antibiotics might prove useful in bacterial analysis, the situation is not without complicating factors. For example, although most common antagonisms are between organisms of different species, one strain of a species may frequently exert antagonistic effects toward another strain of the same species. Also, antibiotics vary in specificity of action (8).

2. Sulfonamides. Several investigations in recent years on the bacteriostatic effects of sulfanilamide, pyridine and thiazol derivatives have used bacteria within the coliform-typhoid-dysentery group as test organisms. Findings indicated that sulfanilamide could be used in media employed in water analysis, since *concentrations of approximately 100 ppm. had little effect upon the growth of* Esch. coli.

One application of the above finding was made in Honolulu. A high incidence of false positive reactions obtained during the routine bacteriological analysis of water samples from newly installed or newly repaired mains suggested investigations to determine the causative organisms and to devise a medium to reduce *false positive* reactions. In this particular supply, it was demonstrated that the organisms largely responsible for confusing results were *Bacillus polymyxa, Bacillus macerans* and several other forms usually found under similar conditions. Results of experimentation, in which standard lactose broth with 0.01 per cent of sulfanilamide added was used as an initial medium, were favorable. Coliform organisms developed even when present in small numbers without evidence of repression likely to produce false negatives. Moreover, lactose-fermenting, spore-forming bacilli were inhibited when present in large numbers. There was evidence, however, that some of the intermediate strains of coliforms were more sensitive to the presence of the sulfanilamide. This factor must be given consideration in the development of any new technique, since the present standards are based upon the isolation of certain organisms within an arbitrary coliform group rather than of *Esch. coli* alone. Although about 80 per cent of false positives was eliminated by the use of this presumptive medium, those produced by *Proteus* and *Pseudomonas* in association with other microflora components were not inhibited (9).

Investigations recently made at the laboratories of the Los Angeles Dept. of Water and Power using lactose-sulfanilamide media have also produced some favorable findings. In one series, using multiple sample points, there was an average reduction of false positives of over 50 per cent. Results of limited examinations which have been conducted to date have yielded no evidence of appreciable repression of coli-

* Readers with a direct interest in this subject should refer to the article by Rittenberg and Silliker (7).

form organisms. Cultural examination and differential tests indicated that the sporulating organisms present were responsible for the greater number of false positive presumptive tests. It was interesting to note the possible existence of false negatives in standard lactose tubes, since completed recoveries were sometimes higher when the initial medium contained the antibiotic. There was some evidence that presumptive tubes with low gas volumes were produced by synergistic mechanisms. Results to date have been promising, but the number of samples upon which data are available is insufficient to merit any final conclusions. Additional studies are being made so that this antibiotic may be examined further through comparative investigations with standard lactose broth under controlled conditions.

3. *Techniques based on nutritive requirements.* One rather broad approach which offers possibilities of newer bacteriological techniques utilizes variations in nutritive requirements among organisms or groups of organisms as a basis for their separation. It is generally recognized that Gram-positive organisms produce the greater part of spurious presumptive results in the coliform test. It is also known that these organisms are more exacting in their nutritive requirements than the coliform organisms (10). It follows logically that if a medium could be devised in which nutritive elements necessary for the multiplication of interfering forms were absent, the effect of their competition on coliform organisms would be reduced to a minimum. Moreover, the elimination of the necessity for antibacterials would be desirable since the factor of repression induced by most of these agents would be absent. The likelihood of providing optimum conditions for the growth of coliform organisms becomes more evident when it is considered that nutritive or accessory growth factors tending to favor the development of coliform organisms could be added to the medium. The exploratory phases of research employing the principles noted are now in progress at the University of Southern California.

It is apparent that, in addition to the provision or elimination of accessory growth factors in various media, changes in the ordinary nutritive components could be studied with benefit for any of the numerous media in use or proposed for the presumptive or other tests. Reference here is to modifications in the sugar or peptone concentration, selectivity of nitrogen source and the use of a buffer in the formula.

4. *Biochemical techniques.* Although one can only speculate, at present, about biochemical tests for the detection of organisms used in estimations of coliform density, it is believed that they should be included in any general discussion of possibilities which exist.

Most experience with biochemical tests in the water purification field is associated with classification within the coliform group utilized in special procedures. An example of such tests are the *IMViC* reactions of Parr, especially those concerned with the production of acetylmethylcarbinol and indole. Tests of this type, modified for more rapid production and subsequent detection of the substance developed, suggest the basis for an easily read confirmatory test. The likelihood of such a development would depend, of course, upon whether new research pertaining to the physiology of the coliform group reveals some metabolic product or reaction peculiar to the bacteria being used to determine sanitary quality. Unquestionably, some useful suggestion for the improvement of these methods

will be forthcoming from the volume of current bacteriological research.

If the use of antibiotics or other agents suggested by investigations in bacterial selection and inhibition improve the initial medium, it is likely that a biochemical test could be read on the second day. The formation of products of metabolism might be accelerated by changes in the medium so that specific substances would be subject to detection by microanalytical techniques after less than eight hours' incubation.

There are several factors that favor the utilization of biochemical tests for the detection of coliform organisms. These are so widely used in research that considerable data concerning their physiological reactions are available. In addition, under certain conditions, products of metabolism are formed in amounts sufficient for detection in a relatively short period, since coliform organisms have a generation time of less than twenty minutes.

It cannot be too strongly emphasized that the realization of this type of simplified procedure depends upon the previously noted factor of how selective and sensitive an initial medium might be developed. The complexity introduced into such methods by the broad range of coliform organisms currently used as an index, as contrasted with the use of *Esch. coli*, is evident here, as in the possibilities previously discussed.

5. *Electron microscope.* The electron microscope has in a relatively few years given indications of extensive usefulness in such diverse fields as biology and metallurgy. It was anticipated that attempts would be made to apply this instrument to the solution of the myriad problems in the field of water microbiology. General knowledge concerning the refinement of the electron microscope at present and certain inherent limitations made it evident, however, that, though useful as a research tool, its application to routine procedures would be quite unlikely. In consequence, only rarely have attempts been made to attain routine use of the device, especially in the field of water purification and sanitation.

The electron microscope has proved of great value in obtaining new knowledge as well as in substantiating previous findings which were inconclusive because of the limit of resolution of optical systems. Such results, however, have been secured at the expense of intensive research procedures.

The examination of biological material with this instrument is limited. Disappointment was expressed even in the early phases of study over the fact that so little could be discerned of the fine inner structures in the protoplasm of bacterial cells. Visualization is further affected by the production of artifacts during preparative procedures in which cells are subjected to dehydration and later to electron bombardment while in an evacuated column.

It is obvious at the outset that these shortcomings form a barrier against the use of this instrument for routine identification procedures. Moreover, the generally known characteristics of the coliform group make differentiation on the basis of morphology alone virtually impossible at the present stage of knowledge. Although it is certain that chromatinic structures are present in some bacteria, their use for identification purposes is improbable. The fact that present standards are based upon confirmed or completed isolation of coliform organisms rather than *Esch. coli* further complicates this matter.

Experimental attempts, are being made at the Chicago South Dist. Fil-

tration Plant to facilitate and shorten testing procedures through the use of the electron microscope (*see* p. 66). Results have not been too encouraging since, as would be expected, enrichment of the sample in a manner similar to that required by the presumptive test is a necessary preliminary. In the author's opinion, the introduction of this time factor, in addition to lengthy preparative procedures, has not significantly decreased the period required to obtain useful information. Thus, little improvement over present methods of testing could be realized. One reason given for lack of encouragement has been the expense of keeping the equipment in operation. It is readily understandable that the volume of work necessary in routine practice would make operation and maintenance much more costly than in research applications.

Experience with the electron microscope at the laboratories of the Los Angeles Dept. of Water and Power indicates that, in addition to personnel for interpreting micrographs concerned with their respective fields, it is necessary to employ a full-time technician to prepare material and operate and maintain this equipment. Such personnel should have a fairly broad scientific background and some training in practical electronics. Problems arise over the interpretation of micrographs because of the basic differences between an image produced by visible light and one produced by electrons. For this reason, it is desirable for staff chemists and bacteriologists who ultimately study micrographs to take courses in electron microscopy which will aid in their interpretation of findings.

It cannot be too strongly emphasized that the electron microscope at the present stage of refinement is definitely not a routine instrument. Its value in research, however, is unquestioned.

Summary

1. Several of the newer bacteriological techniques do present possibilities which might be utilized for the development of improved coliform tests. It appears that these innovations should be applied largely to the presumptive test, in which the elimination of undesired forms would best serve to facilitate and reduce procedures concerned with isolation.

2. In order to effect better sanitary control through increased testing frequency, the time required for routine examination should be reduced. Investigations utilizing agents and devices to accomplish this end require an extensive reexamination of procedures used to determine the sanitary quality of water. Moreover, the complexity of problems attendant to isolation necessitates concentration of research on the application of techniques to the coliform test when mixed cultures are employed.

3. Antibiotics and sulfonamides make possible the improvement of the coliform method since their selective action is effective in differentiating bacteria. The outstanding quality of these agents is that their mode of action depends upon interference with certain individual reactions rather than the interruption of metabolism as a whole, such as characterizes classical antibacterials. At present research conducted with these substances in this field is too limited to determine whether undesirable forms could be eliminated without repressing coliform organisms. Results with other bacteria appear favorable, however.

4. Newer techniques in allied fields suggest the application of methods based on differences in nutritive re-

quirements, as it is known that, for bacteria associated with spurious results, these requirements differ markedly from those of coliform organisms. In addition, the use of materials to inhibit Gram-negative noncoliform organisms and various combinations of antibiotics and alterations are suggested. Some might be studied with equal benefit in numerous media already in use or proposed.

5. Biochemical and other related tests are employed primarily in specialized differential coliform investigations used to determine the types present. Their application to the improvement of routine coliform methods which precede estimation of density can be considered chiefly as speculation at present.

6. Improvement in methods based upon morphological considerations is not indicated from available data. Significant reduction in testing time by such methods is unlikely, since enrichment and other phases of cultural practice are necessary. In addition, the extensive preparative procedures necessary for visualization with the electron microscope are time-consuming and not adapted to routine practice.

7. Past experience and recent data substantiate the fact that differences in waters present a formidable impediment to the development of ideal procedures based upon any technique of coliform density determination. Each water or related type may demand a unique medium. Some workers have suggested that the problem may require an entirely new approach.

Acknowledgment

The author wishes to express his appreciation to Sydney C. Rittenberg and John H. Silliker of the University of Southern California for providing a manuscript of an unpublished paper on the use of antibiotics in presumptive media. The author is grateful to A. J. Salle of the University of California at Los Angeles for some of the reference material.

References

1. Wattie, Elsie. Relative Productivity of Newer Coliform Media. Public Health Repts., **63**:269 (1948).
2. Waksman, S. A. & Woodruff, H. B. *Actinomyces antibioticus*—A New Soil Organism Antagonistic to Pathogenic and Nonpathogenic Bacteria. J. Bact., **42**:231 (1941).
3. Schoenbach, E. B. & Seidman, L. R. A Selective Medium for Isolation of *Hemophilus influenzae*. *Proc. Soc.* Exptl. Biol. & Med., **49**:108 (1942).
4. Fleming, A. On the Antibacterial Action of Cultures of a Penicillium With Special Reference to Their Use in the Isolation of *B. influenzae*. Brit. J. Exptl. Path., **10**:226 (1929).
5. Pratt, Robertson & Dufrenoy, Jean. Cytochemical Mechanisms of Penicillin Action. IV. Comparative Responses of Gram-positive and Gram-negative Bacteria to Penicillin. J. Bact., **54**: 719 (1947).
6. Dubos, R. J. Bacteriostatic and Bactericidal Agents Obtained From Saprophytic Microorganisms. J. Pediat., **19**:588 (1941).
7. Rittenberg, Sydney C. & Silliker, John H. Use of Antibiotics in the Presumptive Medium for Water Analysis. Am. J. Pub. Health, **39**:1553 (1949).
8. Waksman, Selman A. *Microbial Antagonisms and Antibiotic Substances.* The Commonwealth Fund, New York (1945).
9. Tidwell, W. L. & Bushnell, O. A. Lactose-Sulfanilamide Broth Medium for Reducing Number of False Positive Presumptive Tests in the Bacteriological Analysis of Water. M.S. Thesis, Univ. of Hawaii (1948); *abstracted*, Jour. A.W.W.A., **41**:308 (April 1949).
10. Peterson, W. H. & Peterson, Mary S. Relation of Bacteria to Vitamins and Other Growth Factors. Bact. Revs., **9**: 49 (1945).

Use of Electron Microscope in Water Treatment Control

By John R. Baylis

A paper presented on Oct. 12, 1949, at the Wisconsin Section Meeting, Milwaukee, Wis., by John R. Baylis, Engr. of Water Purif., South Dist. Filtration Plant, Chicago.

THE electron microscope is an instrument that magnifies objects considerably more than the conventional light microscope. With the aid of photographs, the larger electron microscopes may show objects enlarged 50,000–100,000 times, while the range of the smaller instruments is 30,000–50,000. Many of the bacteria when magnified 20,000–30,000 diameters will measure 0.4–0.8 in. in diameter and 1–3 in. in length on the photograph. This is large enough for the outside shape of the bacteria to be distinguished very well. Identification by morphology therefore becomes a possibility, although the internal parts of such objects are not shown so well by the electron microscope. At the Chicago South Dist. Filtration Plant, a light microscope with magnification close to 100 diameters is used for plankton work and the species are identified almost exclusively by shape and internal characteristics.

The microscope shown in Fig. 1, which was installed at the plant in the latter part of 1947 (1), is the console type manufactured by the Radio Corp. of America. It has electronic magnification of 500 ×, 1,500 × and 5,000 ×. The additional magnification shown on photomicrographs has to be obtained by photographic enlargements. The manufacturer claims the electron microscope is 20 times more powerful than the finest light microscope.

Electron "light" has a much smaller wavelength than ordinary light; therefore, smaller particles can be photographed. Thirty Angstrom units (0.003 μ or 0.00000012 in.) is about the limit of particle size that may be photographed with the larger electron microscope, and 100 Å (0.010 μ) with the smaller instruments.

Instruments based on electron emission must have means of getting the electrons out of the cathode and making them travel along desired paths. Examples of present-day use of electronic emission other than the microscope are radio and television camera tubes and photocells. Heating a metal filament such as tungsten to high temperature is a common method of producing electronic emission.

Description of Microscope

The electrons from the filament are focused on the specimen by the magnetic condenser. Some of the electrons are absorbed by the specimen and others are scattered at various angles. Some of the scattered ones lose speed. Only electrons that pass through or close to the specimen without loss of speed reach the photographic plate, a

diaphragm being used to remove many of the scattered electrons.

The electron source, called the "electron gun," is composed of a tungsten filament, easily removable for replacement. The potential of the accelerating supply is 30,000 v. The other components of the microscope include the anode and aperture assembly, the specimen holder, magnetic lens system, pole piece, viewing chamber and camera mechanism.

As the electron gun is in close proximity to the specimen stage, there must be a means of reducing the heat produced by electron bombardment and infrared radiation. The anode, which is made of heavy copper and is in contact with the specimen chamber, removes much of the heat.

The magnetic lens system is between the viewing and specimen chambers. One electromagnet provides the magnetomotive force for the iron of the pole piece system, which is arranged to include two gaps in series in the magnetic circuit.

Although the microscope gives a maximum magnification of 5,000 ×, the laboratory workers prefer to use a magnification of 1,500 × for most work. This magnification is obtained by disconnecting the high-gain insert assembly and leaving off the piece holding the inner aperture. With a 10 : 1 or 15 : 1 photograph enlargement, the object is magnified 15,000–21,000 diameters. A particle of 100-Å diameter must be magnified about 1,500 times, and the photographic image enlarged 7 times (10,500 diameters), to be seen with the eye.

FIG. 1. Console Model Electron Microscope

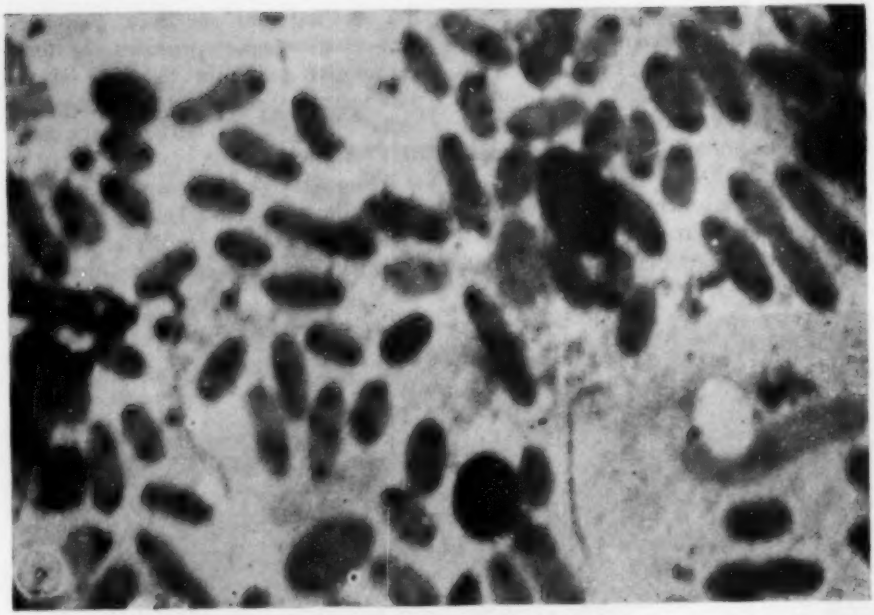


FIG. 2. Raw-Water Photomicrograph (5,000 ×)

FIG. 3. *Escherichia coli* (15,000 ×)

The viewing chamber is provided with a leaded glass viewing window which has a fluorescent inner surface. This special conducting glass, 4 in. in diameter, allows charges which may accumulate as a result of the electron bombardment to be dissipated from the fluorescent surface, and thereby prevents image distortion. The lead in the glass shields the operator from any random X-rays. The viewing chamber houses the camera mechanism.

The specimen screens are discs of 200-mesh wire screen $\frac{1}{8}$ in. in diameter. For bacteriological and most other work the screen is coated with a collodion film.

The electron beam requires an evacuated column. A high vacuum (0.0001 mm. Hg or better) is obtained by the use of a fore pump in series with an oil diffusion pump. The fore pump is operated by a $\frac{1}{2}$-hp. motor. The two-stage, air-cooled diffusion pump is heated by a 135-w. heater.

In starting, fifteen to twenty minutes is required to warm up the pumps to produce the desired vacuum. Afterwards, air let into the column for specimen or camera changes is exhausted in three to five minutes. The pressure reduction which can be obtained is influenced by the leak rate of the gaskets. The air which must be let into the column when inserting a specimen or changing the camera plate is passed through an air filter and dried.

The image of the specimen appears on the fluorescent surface of the viewing window which is struck by electrons that have penetrated or pass close to the specimen. Ideally, therefore, the specimen should be less than 1 μ in thickness, because otherwise it generally cannot be penetrated. Specimens that are self-supporting are the best, as the electrons then have to pass through no material other than the specimen. Bacteria and many other objects have to be supported, however.

The formation of a suitable supporting membrane is not easy, for it must be strong enough to support its own weight and that of the specimen, and yet can be only a few molecules in thickness. The image produced by the membrane must be structureless and not much different from the image produced by empty space. Collodion is used most extensively although formvar has also proved satisfactory.

If the inside structure of bacteria could be brought out by the electron micrograph, as are the insides of most plankton cells when observed with a light microscope, this would serve as a better means of identification. The micrograph reveals many details of plankton and bacteria not shown by the light microscope, yet other details essential for identification often are not visible. The number of species of bacteria likely to be present in water may be large, greatly lessening the accuracy of any identification by shape alone.

The shape of plankton varies widely and there is also color variation in many species. Identification by shape and color makes possible the differentiation of hundreds of species. The various species of bacteria, however, may not show so wide a variation in size and shape. Color, which is often a valuable aid to identification with the light microscope, is not revealed by the electron microscope.

Use of Electron Microscope

At present the South Dist. Filtration Plant is using the electron microscope almost exclusively for bacteriological work. An attempt is being made

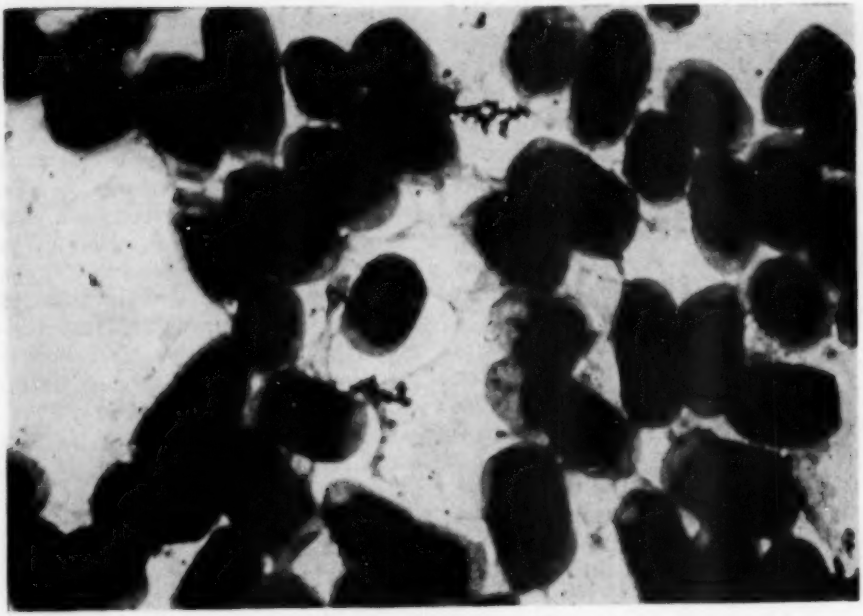


FIG. 4. *Aerobacter aerogenes* (18,000 ×)

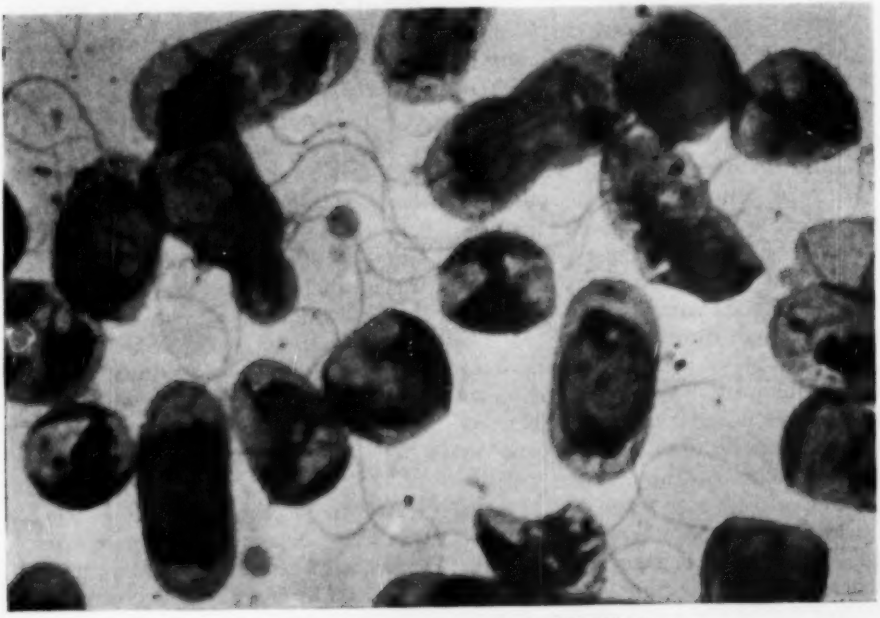


FIG. 5. *Pseudomonas aeruginosa* (20,000 ×)

to determine if it is possible to obtain identification of coliform bacteria in water within shorter periods than are required by *Standard Methods*. The water samples are inoculated in lactose broth in accordance with the usual *Standard Methods* procedure, and those showing presumptive evidence of coliform bacteria are selected for examination under the electron microscope. Transfers from the positive presumptive tubes are first made to the brilliant green bile and sometimes to other culture media. The tubes are then turned over to the electron microscope room.

A portion of a sample is placed on one or more screens covered with a collodion film and allowed to dry. Next the specimen-coated screens are washed by dipping them for about ten seconds into a solution of alcohol containing 10 per cent chloroform. After drying, the specimen is dipped into a 1 : 1 mixture of carbon tetrachloride and chloroform for about twenty seconds and dried once more. The specimen is then submerged in pure carbon tetrachloride for about 1½ minutes, washed with water, dried and put back in the carbon tetrachloride for five minutes or more. The specimen may remain in the solution for several hours without injury to itself or to the film. This procedure washes the specimen and also seems to toughen the collodion film on the wire screen. When dried, the specimens are ready for examination with the microscope.

FIG. 6. *Bacillus subtilis* (7,500 ×)

The observer examines the bacteria that are projected on the viewing screen. The field can be moved so as to examine more of the specimen if desired. The bacteria are compared with micrographs of known coliform

organisms or are identified from previous knowledge of the shape and characteristics of such bacteria. If organisms are found that resemble coliform bacteria, the specimen is recorded as positive. If none of the bacteria present resembles coliform bacteria, the specimen is recorded as negative.

A summary of 2,000 positive presumptive tubes (lactose broth, 24 and 48 hours) from various sources—raw, chlorinated and filtered water—which were tested with the electron microscope is given in Table 1. It will be noted that correct identification was obtained with the microscope in 1,838 tubes, or 91.9 per cent of the total. For the 1,065 tubes from raw-water samples, 87.1 per cent of the tests were in agreement with *Standard Methods*, while for the 935 treated-water tubes, 97.4 per cent were in agreement.

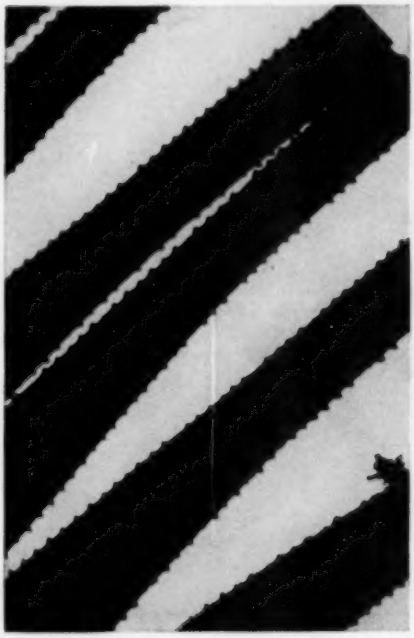


FIG. 7. Portion of *Fragilaria* Cells (10,000 ×)

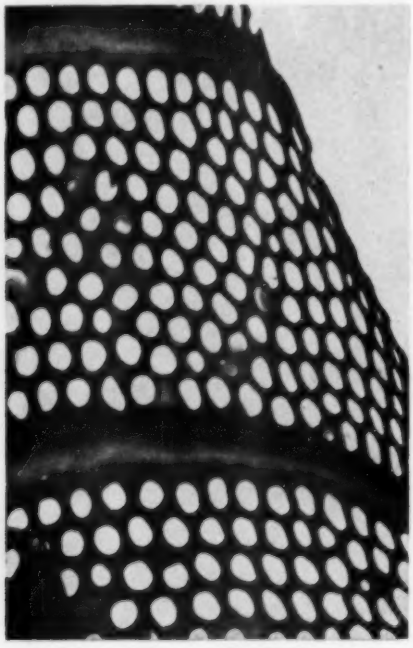


FIG. 8. Portion of *Rhizosolenia* Cell (15,000 ×)

Time Required for Test

An effort has been made to determine the shortest time in which bacterial identification may be made in a sample of water with the electron microscope. It is, of course, necessary to await the growth of a large number of bacteria in the culture medium before attempting to transfer a specimen to the microscope. In some samples, growths of sufficient concentration for testing have been obtained in ten to twelve hours. Gas usually does not start developing in lactose broth before fifteen or twenty hours' incuba-

tion. All samples, or at least those showing any cloudiness of the medium, would have to be tested if the full incubation period for the presumptive test were not used, thus increasing considerably the number of tubes to be examined.

For detection to be made without culturing the organisms, bacteria would have to be present in the samples in enormous numbers, a condition which is to be expected only in highly polluted water. Figure 2 is a photomicrograph of a water sample from one of the pumping stations which showed a high coliform bacteria count. This is one of the very few samples in which the bacteria were sufficiently concentrated for testing without growth in culture media.

TABLE 1

Comparison of Electron Microscope and Standard Methods *in Coliform Organism Determinations*

Tubes		Test Results	
No.	*per cent*	Electron Microscope	*Standard Methods*
458	22.9	+	+
1,380	69.0	−	−
118	5.9	+	−
44	2.2	−	+

After the bacteria have reached a concentration sufficient for the selection of a specimen, the time required to mount the specimen on the wire screen, prepare it for the microscope and make an observation is about two hours. If a photomicrograph is made, the time is about three hours. Because of the ten- to twelve-hour incubation period and the two- to three-hour testing period, the shortest time in which coliform bacteria may be detected is twelve to fifteen hours. Not much is lost in awaiting the regular *Standard Methods* presumptive test of 24 hours before using the electron microscope.

Photomicrographs

Photomicrographs of *Escherichia coli, Aerobacter aerogenes* and *Pseudomonas aeruginosa* are shown in Fig. 3–5, respectively. There was considerable penetration of the electrons in the specimen in Fig. 5, and the inside structure of the organism is revealed more clearly than is usual for the other bacteria. In fact, the field includes organisms in various stages of division—a most interesting picture. Good penetration also was obtained in Fig. 6 on a specimen of *Bacillus subtilis*.

FIG. 9. Aluminum Hydroxide Coagulation (10,000×)

Some use of the microscope has been made to study algae and other such microscopic organisms. The micro-

scope could not be used for plankton counting although it might be employed to study the characteristics of some of the organisms, particularly those that retain their shape after drying. Figures 7 and 8 are photomicrographs of diatoms that occur abundantly in Lake Michigan water at certain seasons of the year. The filter plant biologists had not been aware of the sawtooth structure of *Fragilaria* and had often wondered how these organisms were held together in long rafts of cells. The electron microscope revealed a zipper-like binding near the middle portion of the cell. The microscope also showed the symmetrical and open, lacelike structure of *Rhizosolenia*. Revelation of such facts may constitute the only value of the microscope in plankton work. It will not be of much use in studying organisms that change their shape considerably on drying.

Coagulation Studies

So far not much work has been done in the South Dist. Filtration Plant laboratory on coagulation. It is hoped that the microscope will give some aid in obtaining better knowledge of the characteristics of the precipitates produced in water treatment. The fact that the precipitate has to be dried before being observed with the microscope may cause its structure to change considerably. Photomicrographs of coagulation (Fig. 9) give some evidence of fibrous or brushlike formation. Drying the precipitate may have had much to do with the shapes shown.

It is known that gelatinous precipitates are extremely porous. Jelly-like substances, such as the agar plates used in bacteriological work, contain only a very small percentage of agar. If only 1.5 per cent agar is used, the jelly is 98.5 per cent water. The jelly, however, is held together in some manner by solid fibers or membranes that do not flow like water, and it can only be assumed that it is built up of a meshwork of entangled fibers.

It is planned to use the electron microscope in further studies of coagulation even though the work so far done along these lines is not very encouraging.

Maintenance

The electron microscope was installed in November 1947 and has received considerable use, although nothing near constant eight-hour daily operation. Operating troubles, both mechanical and electrical, have been greater than expected and have caused the machine to be out of service on several occasions for a week or more. In the routine operation of a water treatment plant, instruments of greater reliability are required. It is hoped that the trouble experienced in keeping the instrument in working order will be much less in the future.

Reference

1. DeBerard, W. W. & Baylis, J. R. New Vistas in Water Quality Research. Eng. News-Rec., **140**:639 (April 2, 1948).

High-Capacity Cation Exchangers

By F. K. Lindsay

A paper presented on Nov. 15, 1949, at the Florida Section Meeting, Orlando, Fla., by F. K. Lindsay, Asst. Mgr., Zeolite Dept., National Aluminate Corp., Chicago.

INORGANIC base-exchange materials have been used in softening water for more than 40 years. The products commonly referred to as zeolites, which have been most widely used for this purpose, constitute only one division of a rapidly growing group of ion exchangers. The ion exchangers are divided into two broad classes—the cation and anion exchangers—which are further subdivided into inorganic and organic materials:

1. Cation exchangers
   - *a.* Inorganic
     - (1) Natural (greensand)
     - (2) Synthetic (gel zeolites)
   - *b.* Organic
     - (1) Natural (lignites)
     - (2) Sulfonated coal (carbonaceous zeolites)
     - (3) Synthetic resins
       - (a) Phenolic
       - (b) Nonphenolic
2. Anion exchangers
   - *a.* Inorganic—metallic oxides
   - *b.* Organic—synthetic resins

Generally speaking, all of the cation exchangers can be regenerated with common salt and used for removing calcium and magnesium from solutions. The organic cation exchangers, such as the carbonaceous zeolites and the synthetic resins, can also be regenerated with dilute acid solutions and, in the resulting hydrogen condition, they will remove all metallic cations (sodium, potassium, calcium, magnesium, iron, copper and manganese) from solution. The anion exchangers, regenerated with either sodium carbonate, caustic soda or ammonia, are used to remove the acid ions, such as the sulfates, chlorides and nitrates, from solution. Although, as indicated by the classification table, both inorganic and organic anion exchangers have been made, only the organic (synthetic resin) anion exchangers are used widely at the present time, since the inorganic materials do not have the proper characteristics for deionization application. The complete deionization process, which consists of passing water through a cation exchanger regenerated with dilute acid and then through an anion exchanger, produces a finished water comparable to distilled water in quality. In fact, recent work employing a mixture of a strongly acidic cation exchanger and a highly basic, quaternary amine type of anion exchanger in a single bed has produced water with an electrical resistance of between 10 and 20 million ohms per centimeter.

The organic materials of this ion exchanger class, of comparatively recent development, are applicable to the handling of many problems for which the older, better known zeolites could

not be used. Electrolytic impurities in aqueous solutions of nonelectrolytes can be removed by the complete deionization process. For example, in the sugar beet industry, the inorganic ash may be eliminated from the sugar juice by passing it through a cation-anion plant, thereby materially increasing the yield of crystallizable sugar and reducing evaporator scale and operating difficulties. The removal and recovery of small amounts of metallic ions such as copper, nickel and aluminum can be accomplished by employing an organic cation exchanger. The metal can then be recovered in more concentrated form by reconditioning the exchanger with a regenerant of the desired concentration.

Zeolites

"Zeolites" are usually given these exchange capacity ratings (grains per cubic foot as $CaCO_3$): greensand, 2,800–3,000; high-capacity greensand, 4,800–5,000; and synthetic gel type zeolite, 10,000–12,500. Since 1947 increased capacities have been obtained in the synthetic gel type zeolites by improved processing techniques which have resulted in closer control of particle size or grading. Formerly products of this type were either very coarse (with 80–90 per cent of the product coarser than 20 mesh) or unusually fine (largely 30–60 mesh in grading). Present products, mostly of 16–40 mesh in grading, are available with capacity ratings of 12,000–16,000 gr. (grains) per cubic foot, depending upon the quantity of salt used for regeneration.

In the organic class, the carbonaceous zeolites (sulfonated-coal products), which are the oldest and perhaps best known, were introduced in the 1930's. These materials are rated at capacities of 5,000–7,000 gr. per cubic foot. The synthetic-resin cation exchangers date back to 1935. The first of this group to appear commercially was the "phenolic" or "phenol-formaldehyde" resinous exchanger. Current products of this class are actually sulfonated phenol-formaldehyde resins, which have exchange capacity ratings of 6,000–18,000 gr. per cubic foot, depending on the particular product under consideration and the quantity of regenerant used in its operation.

Although both the carbonaceous zeolites and the phenol-formaldehyde resins are definitely suitable for many water-softening and ion-exchange uses, their applicability is somewhat limited by their instability at elevated temperatures or high pH and in the presence of oxidizing agents such as chlorine.

Styrene Base Resins

Probably the most outstanding development of the past three years in ion exchange products used for water softening has occurred in the nonphenolic-resin cation exchangers. Materials of this class are made by copolymerizing styrene with divinylbenzene and sulfonating the resulting copolymer. These exchangers have outstanding operating characteristics.

The nonphenolic (styrene base) resins have capacity ratings of 25,000–30,000 gr. per cubic foot, depending on the quantity of salt used for regeneration. Products of this type exhibit a high exchange capacity on low salt consumption. Aultman and Bowers state (1) that: "the nonphenolic base resins appear to withstand the oxidizing effect of low concentrations of chlorine. In addition, they are able to operate at an exchange capacity of 20,000

gr. per cubic foot at a salt efficiency of 0.25 lb. per kilograin of hardness removed without any apparent deleterious effect."

This characteristic has been verified further at the Memphis, Tenn., plant of the Quaker Oats Chemical Co., where, after more than two years of operation, the nonphenolic exchanger is maintaining a capacity of 23,000–24,000 gr. per cubic foot on a salt consumption of 0.25 lb. per kilograin of hardness removed. The exchange capacities referred to above are summarized in Table 1.

TABLE 1

Exchange Capacities

Material	Capacity *gr./cu.ft.* (as $CaCO_3$)
Greensand	2,800– 3,000
High-capacity greensand	4,800– 5,000
Synthetic gel type zeolites	10,000–12,500
Super gel type zeolites	12,000–16,000
Carbonaceous zeolites	5,000– 7,000
Phenolic resins	6,000–18,000
Nonphenolic resins	24,000–30,000

Physical Stability

Accelerated tests conducted in the laboratory indicate that the styrene base nonphenolic cation exchangers are exceedingly resistant to physical wear or attrition. These tests are conducted by placing a standard quantity of material in a 4-oz. bottle and covering it with water. The sample is then tumbled end-over-end on a rotating wheel for a number of hours so that the particles constantly rub against each other, much as they do in the zeolite backwashing operation. By subjecting different products to exactly the same test conditions, some evaluation of their comparative abilities to resist attrition can be made. In this test, the nonphenolic resin shows greater resistance than the older synthetic zeolites.

Chemical Stability

The chemical stability of the nonphenolic styrene base products has been demonstrated through some unusual applications. In the ion-exchange purification of milk whey used in the preparation of pure lactose sugar, acid-insoluble proteins separate out on the surface of the cation exchanger, thereby reducing its ion-exchange capacity. In considering a solvent for the elimination of this surface contaminant, caustic soda solution seemed a logical choice, but, since it was known to have a detrimental effect on the inorganic zeolites and the phenol-formaldehyde resins, it was first applied in a 2 per cent solution at room temperature to the styrene base resins. When it was found that the resin was stable at that concentration of sodium hydroxide, 4 per cent and 8 per cent solutions were tried. To obtain more rapid solution and test the stability of the resin further, it was treated with 8 per cent sodium hydroxide at 150°F. As a check on stability only, the resin was digested in an 8 per cent sodium hydroxide solution at 150°F. continuously for 30 days. At the end of this period the resin was evaluated for exchange capacity and physical condition. The results indicated that the material had undergone no physical or chemical depreciation and had suffered no loss in exchange capacity.

The stability of the nonphenolic resins at elevated temperatures has been demonstrated at the Quaker Oats Chemical Co. Memphis softening plant, where the raw water is first used for cooling purposes before passing through

the resin to be softened for subsequent application as boiler feedwater. This water supply, therefore, always carries a temperature of approximately 160°F. as it enters the resin bed.

A further and more severe test of the ability of the nonphenolic resins to withstand high temperatures is being provided by pilot plants for the removal of residual hardness following hot-process lime-soda softening. In these applications, the resin is being used on water which has not only a temperature of 220°–230°F. but also a pH of 10. Tests such as those just referred to have, therefore, established the stability of the resin to boiling and even higher temperatures.

Inasmuch as these high-capacity styrene base resins owe their exchange capacity characteristics to the presence of sulfonic acid groups, introduced by treating the base resin with concentrated or fuming sulfuric acid, it is readily understood that products of this type will not be adversely affected by treating water or liquids of low pH. Removal of calcium and magnesium from liquids at a pH of 3–3.5 has been carried out successfully without detriment to the resinous ion-exchange material.

TABLE 2

Nonphenolic Styrene Base Resin Capacity

Bed Depth in.	Flow Rate gpm./sq.ft.	Downflow							Upflow			
		NaCl (10% Solution)—*lb./cu.ft.*										
		15		6		15			6			
		Regeneration Cycle—*min.*										
		60*	30*	60*	30*	30†	60‡	30‡	60*	30*	60*	30*
		Capacity—*kgr./cu.ft. as $CaCO_3$*										
30	5	33.1	27.7	25.2	23.0	33.0			33.2	29.5	24.0	20.4
30	10	32.0	27.4	24.1	23.0	33.0			31.2	25.1	22.9	18.2
30	20	30.0	26.2	21.1	20.0	29.5			30.6	25.0	22.4	16.7
15	2.5	31.1	27.0	23.5	20.0	30.4	27.2	22.1	32.6	28.4	23.0	21.0
15	5	30.6	26.5	21.3	20.0	29.5			32.0	27.8	23.0	20.5
15	10	28.0	26.0	20.8	19.8	29.5	26.4	21.7	30.6	27.1	22.4	20.5
7.5	1.25	30.4	28.0	17.0	16.0	29.5	26.0	22.5	32.0	25.0	20.0	20.4
7.5	2.5	27.0	26.0	17.0	15.0	28.8			30.1	25.0	19.0	18.5
7.5	5	26.5	23.0	15.1	15.0	26.0	26.0	22.5	30.0	25.0	18.1	16.1
26.5	17.5						29.8					
26.5	17.5						28.2§					
40	25						30.5					

* Laboratory test; brine at room temperature.
† Laboratory test; brine temperature 150°F.
‡ Field test.
§ Regenerated by siphoning saturated solution equivalent to 15 lb. NaCl per cubic foot into freeboard filled with water.

In the industrial softening of Great Lakes water by means of the inorganic gel type zeolites, depreciation of the zeolite due to the comparatively low silica content of the water being softened has always constituted a problem because of the leaching of silica from the zeolite. Since the polystyrene resins have an organic base structure in contrast to the siliceous "backbone" of the inorganic gel zeolites, waters of low silica content can be softened by them without resin depreciation.

Stability to Oxidizing Agents

In contrast to the sulfonated coal and phenol-formaldehyde classes of ion exchangers, products of the styrene base type are exceedingly stable to oxidizing agents such as chlorine. Because chlorine even in low concentrations is only partially adsorbed by these resins, it can readily be used as a disinfecting agent for bacterially fouled beds.

Flow Rate and Direction

Tests conducted in the laboratory and verified in field research units show that the styrene base resins can give efficient operation at flow rates as high as 20 gpm. per square foot of bed area with normal bed depths of 30 in. Although the use of very shallow beds is not recommended, data obtained indicate that these resins can also give efficient performance when used at standard flow rates of 5 gpm. per square foot through beds only 7½ in. in depth.

Although these high-capacity resin exchangers are normally operated "downflow," test data indicate that they can be just as effective "upflow," so long as sufficient freeboard is provided to prevent loss of resin during the softening operation. Table 2 gives the results obtained with varying flow rates and bed depths for both upflow and downflow operation.

Iron and Manganese Removal

The styrene base resins are capable of removing soluble iron and manganese effectively during the normal water-softening cycle. In softening an iron-bearing water, the iron will appear in the treated water practically simultaneously with hardness "breakthrough." Higher iron concentrations are encountered in domestic than in industrial or municipal water softening. There appears to be no limit to the concentration of iron that can be removed by the resins as long as it remains in a soluble (ferrous) condition. Combinations of hardness, iron and manganese, with manganese concentrations as high as 6 ppm., have been satisfactorily handled with the resins.

TABLE 3

Expansion Characteristics

Flow Rate *gpm./sq.ft.*	Expansion *per cent*
4	25–33
5	35–40
6	45–55
8	65–75

Regeneration With Sea Water and Natural Brine Wells

Because of the interest being shown by municipalities in these high-capacity, stable resins, they have been subjected to capacity evaluation using sea water and natural brine wells for regeneration. Figure 1 gives the capacities obtainable with sea water and with brines from wells in which the salt

concentration is even lower than in sea water.

Physical and Operational Data

The nonphenolic cation exchangers have an apparent density of 48–52 lb. per cubic foot at a moisture content of 35–45 per cent. The usual grading is 16–50 mesh. Products of this class give most favorable capacity performance in the sodium cycle when regenerated with salt solutions 10 per cent

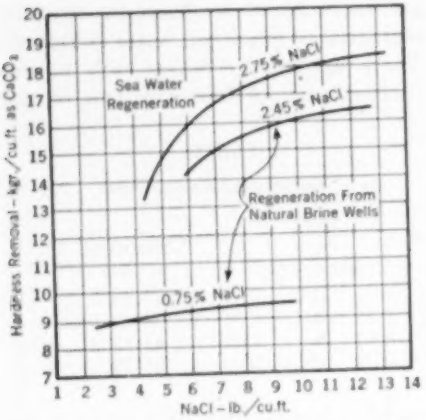


Fig. 1. Sea Water and Natural Brine Well Regeneration

or higher by weight. A minimum of 60 minutes for salt brine introduction and subsequent rinsing is preferred. Rinse requirements range from 30 to 50 gal. per cubic foot. A freeboard space of 50–75 per cent of the depth of the resin should be provided to prevent loss of resin during backwashing. Table 3 gives the expansion characteristics of these materials for upflow operation at temperatures between 60° and 80° F.

Because the nonphenolic resins are capable of giving unusually high capacity performance at excessively high operating rates of flow (as shown in Table 2), it is important to know their head loss characteristics at various flow rates and bed depths. These data are given in Fig. 2.

Conclusion

The development of the nonphenolic styrene base materials has provided a class of ion exchangers capable of giving high water-softening capacity at low salt regenerant consumption. Their excellent chemical and physical stability characteristics make these products admirably suited to all domestic, industrial and municipal water-softening applications.

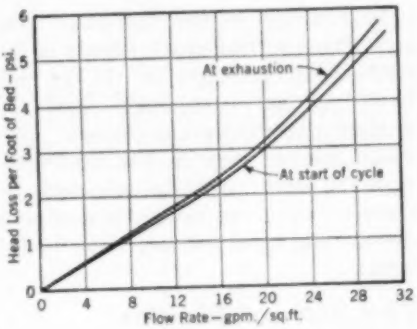


Fig. 2. Head Loss Characteristics

Reference

1. Aultman, W. W. & Bowers, A. E. Use of Organic Cation Exchangers for Municipal Water Softening. Proc. 9th Ann. Water Conf., Eng. Soc. of Western Pa. (1948).

Cation Exchangers for Municipal Water Softening

By Lee Streicher and A. E. Bowers

A paper presented on Oct. 27, 1949, at the California Section Meeting, Sacramento, Calif., by Lee Streicher, Chief Chemist, and A. E. Bowers, Research Chemist, Metropolitan Water Dist. of Southern California, La Verne, Calif.

ECONOMY of operation and life expectancy are the two most important factors to be considered in the selection of base-exchange materials for municipal water softening. The recent development of high-capacity resinous exchangers has more than met the need for adequate capacity in ion exchangers, making it a less critical factor than it was in former years. Exchange capacity, therefore, will be considered only insofar as it affects the economy of softener operation and serves as a measure of the useful life of the exchange material. Salt efficiency and life expectancy, including the effect of small dosages of chlorine on the organic exchangers, will serve as the basis for evaluating the several types of exchangers tested.

Introduction

When the softening plant of the Metropolitan Water Dist. of Southern California was first placed in operation in 1941, no reliable data were available on the operating characteristics of synthetic zeolites. The 26,400 cu.ft. of this material initially installed in the plant gave satisfactory results, with only a slow rate of decrease in efficiency, for the first 3½ years, during which 700,000 gal. of water was treated per cubic foot of zeolite. Subsequently, however, the exchange capacity dropped more rapidly until it reached a level of about 60 per cent of the original capacity. At the same time the salt consumption increased to a value about 72 per cent higher than the original. The results of the work done by the district to determine the cause of this loss in efficiency have previously been reported (1).

In order to increase the operating efficiency, the district revivified its original zeolite after several years of operation. New zeolite was installed in some units to make up the volume loss resulting from the revivification process. Examination of plant operating data since revivification indicates that there has been a gradual loss in exchange capacity and a corresponding decrease in salt economy for both the old and the new zeolites. At that time, because reliable data on life expectancy of the resinous ion exchangers were lacking and the unit cost of these materials was so high, the district did not feel it could install one of them in the softening plant. As a result of this later experience, a research program was instituted to determine life expectancy as well as operating economy, under district conditions, of all available ion exchangers.

It cannot be too strongly emphasized that all data and conclusions are based on tests run with Colorado River water under the district's conditions of pretreatment and softener operation.

The average quality of the water used for most of the test work is shown in Table 1. These conclusions may or may not be applicable to similar tests on the same types of exchangers when another type of water is used.

Scope of Tests

The term "zeolite," as used in this paper, means only synthetic siliceous zeolite. The organic cation exchangers commonly used for water softening can be divided into the three general classes of carbonaceous, phenolic and high-capacity polystyrene, depending upon their basic structure. All rely principally upon sulfonic acid groups for their exchange properties. Except where specifically indicated, the results for all the ion exchangers will be reported as averages for all the materials of the same type. In a previous report (*2*) it was shown that the exchange capacity, color-throw, salt consumption and inability to stand up under the oxidizing effect of chlorine made the carbonaceous and the phenolic resins unsuitable for district use.

TABLE 1

Colorado River Water Quality

Constituent	Natural Water *ppm.*	Zeolite Influent* *ppm.*
Silica (SiO_2)	8.5	14.0
Calcium (Ca)	84	63
Magnesium (Mg)	30	30
Sodium and Potassium (Na, K)	107	106
Carbonate (CO_3)	2	0
Bicarbonate (HCO_3)	140	79
Sulfate (SO_4)	314	314
Chloride (Cl)	85	85
Total dissolved solids	701	652
Total hardness as $CaCO_3$	334	281
Carbonate hardness as $CaCO_3$	119	65
Hydrogen ion concentration (pH)	8.3	8.0
Elec. conductiv.—*mho.* $\times 10^6$	1,100	1,010

* Sodium silicate added.

In the early part of 1947, and since then as more new resins became available, samples of organic ion exchangers were obtained from all the manufacturers for test purposes. The exchangers which have been or are being tested include two synthetic siliceous zeolites, two carbonaceous exchangers and five phenolic and three polystyrene resins.

The testing program was set up to determine some of the important characteristics of the new ion-exchange materials and then to observe the changes which take place during use. Most of the tests were designed to simulate the conditions which are adaptable to district use. To this end, the following tests were made:

1. Particle size distribution
2. Expansion during upflow operation
3. Weight per cubic foot
4. Effect of salt dosage on salt consumption and exchange capacity
5. Effect of variation in brine concentration on exchange capacity

TABLE 2

Particle Size Distribution

Sieve No.*		Coarse Zeolite	Fine Zeolite	M.W.D.† Specs.
Passing	Retained on	Per Cent by Weight		
	8	0	0	0
8	10	9.8	0.6	0– 2
10	16	55.6	9.4	1–15
16	20	17.2	28.2	20–40
20	30	8.5	33.4	25–45
30	40	4.8	19.1	10–25
40	50	4.1	7.9	0– 5
50		0	1.4	0

* U.S. Standard Sieve Series.
† Metropolitan Water Dist. of Southern California.

6. Effect of brine contact time on exchange capacity
7. Bacterial growths in ion-exchange layers
8. Life expectancy.

Data presented herein and conclusions reported are based on results obtained from the plant softener units, from ten fully automatic domestic type units purchased specifically for the testing program and from numerous tests run in small, column type units. The plant units, each containing approximately 2,200 cu.ft. of exchange material, provide data on exchange capacity, salt efficiency and life expectancy of four brands of synthetic siliceous zeolites which have been in operation for varying numbers of years. One plant unit containing 2,000 cu.ft. of one of the new high-capacity polystyrene resins has been in operation for six months (450,000 gal. per cubic foot of exchanger). The primary function of the ten automatic units, each of which contains 1¾ cu.ft. of exchanger, has been to aid in the life expectancy determinations for the several types of materials tested. Most of the exchange capacity, salt efficiency, bed expansion, and other miscellaneous tests were run in the 2¼-in. (id.) plastic tubes.

Particle Size Distribution

It has long been known that particle size distribution is very important for proper softener operation. Coarse ion-exchange material will give very poor hydraulic reclassification during backwash when the normal operation is downflow. In upflow softening, channeling and poor base exchange will result when the material is too coarse to be held in full teeter. The other extreme of a fine material will cause excessive head loss when operated downflow, or a loss of material by carryover when operated upflow. If enough freeboard is allowed, a very fine material may be used in upflow operation with a minimum loss of ion exchanger. Even under these conditions, however, the rate of regeneration desired may set a practical limit on the permissible particle size.

Synthetic siliceous zeolites differ from the newer organic resins in density and usually in particle size. Table 2 shows the maximum and minimum particle size which the district has used in the past, as well as the particle size range which has been found to function most satisfactorily. It should be pointed out that the coarse material shown in Table 2 did not function very well under the conditions prevailing at the district softening plant. It was found that, at an upflow rate of 7.5 gpm. per square foot, 57 per cent of the bed did not move at all; for the entire bed, the total expansion was only 10 per cent. If suspended matter is present when such coarse material is used in upflow softening, the lower part of the bed may become clogged, resulting in increased head loss, channeling and loss in exchange capacity. To clean such a bed requires special treatment, such as jetting with water while in upflow operation or removal of the mineral from the bed for washing. Not only are the hydraulic characteristics poor but the operating exchange capacity is lower for the coarser material. It has been found that the exchange capacity of synthetic siliceous zeolites may range from as low as 5,000 gr. (grains) per cubic foot to as high as 13,000–18,000 gr. per cubic foot, depending on particle size and lot (1).

The polystyrene resins received from the manufacturer have never been too coarse. The size of the beadlike particles has usually been very well controlled. The sulfonation step re-

quired to place the ion-exchange groups on the resin at first caused cracking of the beads with consequent production of some unwanted fines. More recently, however, the three manufacturers who produce this type of resin have been able to hold bead breakage to within the range of 6–17 per cent. Resin produced for commercial use usually has a minimum amount (3 per cent) which will pass a No. 50 U.S. sieve. In contrast with the siliceous zeolites, the polystyrene resins do not show any marked variation in exchange capacity for the different particle sizes. Because of the beaded form of the newer resins, the hydraulic characteristics during upflow operation are much better than for the older, granular type materials. A much higher backwash rate can be tolerated before the resin is in danger of carryover. Although it is the recommendation of every manufacturer that the water be clean or filtered before coming to the softeners, occasionally some suspended matter may be present in the softener influent water. When this condition occurs, it has been observed that during backwash the beaded material will rid itself of the foreign matter much faster than the granular resin. Because of the greater expansion and relatively fine particle size of the resins, the suspended matter may pass through the bed during upflow softening.

TABLE 3

Particle Size Distribution for New and Used Zeolite and Polystyrene Resin

Sieve No.*		Zeolite		Resin	
		New	Used†	New	Used‡
Passing	Retained on	Per Cent by Weight			
	8	0	0	0	0
8	10	9.8	0.4	0	0
10	16	55.6	10.6	2.5	2.1
16	20	17.2	15.2	27.7	27.5
20	30	8.5	19.4	47.6	50.4
30	40	4.8	20.2	16.0	18.0
40	50	4.1	18.5	4.1	2.0
50	70	0	6.4	2.1	0
70		0	9.3	0	0
Effective size		0.46	0.23	0.48	0.52
Uniformity coefficient		2.46	2.71	1.74	1.60

* U.S. Standard Sieve Series.
† 2 mil.gal. water softened per cubic foot.
‡ 3 mil.gal. water softened per cubic foot.

Table 3 shows sieve analyses for samples of a siliceous zeolite and a styrene resin, taken when the materials were new and again after they had been in service for 2 and 3 mil.gal. of water per cubic foot, respectively, under district operating conditions. Although the two materials were placed in operation at the same time, 50 per cent more water had been put through the resin because of its ability to exchange ions more rapidly, permitting

a faster rate of softening, and because the greater capacity of the resin allowed more nearly continuous operation with less time out for regeneration. It should be pointed out that the sample of zeolite after use was very friable and some particles were probably broken during screening. The high-capacity resin has lost all of the material passing a No. 50 U.S. sieve and over half of that retained on the sieve.

Weight per Cubic Foot

It has been found that, under district operating conditions, the siliceous zeolites gradually decrease in weight per cubic foot with continued use. This weight loss is due to silica dissolution which results in channeling of the particles and a wasting away as the outer surface becomes structurally weak. It is reflected in a loss of exchange capacity and an accumulation of fines in the bed. In district operation, a sample of zeolite which had a weight of 27.0 lb. per cubic foot (ignited) when new dropped to as low as 16.7 lb. after it had passed 2.0 mil.gal. of water per cubic foot.

Determinations of weight per cubic foot were made on both the new and the used zeolite and polystyrene resin shown in Table 3. For this test, however, the materials were screened and only the No. 20 to No. 30 sieve size was used. The difference in behavior between the two types of materials is clearly demonstrated in Table 4. Whereas the siliceous zeolite showed a pronounced drop in unit weight after 2 mil.gal. per cubic foot had been softened, the resin remained essentially unchanged after 3 mil.gal. per cubic foot had been softened.

Salt Dosage and Brine Concentration

The determination of salt requirements is the most important test as far as the district is concerned, since it is in the regeneration of the plant softener units that the greatest economies can be effected. A very important point which required investigation, therefore, was whether good exchange capacities could be expected even under salt semistarvation conditions. Although the unit savings in salt which result from operating under these conditions may be small, the overall saving increases rapidly when the softeners are in continuous operation on a large scale. For example, during the fiscal year 1948–49, when more than 25 bil.gal. of water was put through the district plant, 15.1 bil.gal. was softened in the zeolite units. About 50,000 tons of salt was required for regeneration purposes. Under these conditions, even a 1 or 2 per cent decrease in salt consumption due to more efficient softener operation would result in a worth-while saving.

TABLE 4

Weight of New and Used Zeolite and Polystyrene Resin

Material	Weight*—*lb./cu.ft.* New	Used
Zeolite	28.4	20.9†
Resin	32.2	32.1‡

* Jarred; oven dry.
† 2 mil.gal. of water softened per cubic foot.
‡ 3 mil.gal. of water softened per cubic foot.

The exchange capacity tests were carried out under very carefully controlled conditions in the plastic tube units. In every test the manufacturers' recommendations on flow rates, salt dosage, brine contact time and brine concentration were taken as a starting point. Then the particular variable under investigation was changed to determine its effect on the exchange capacity. When a new ion exchanger was used, it was recycled several times

before the collection of comparative data was started, in order to remove all soluble foreign matter which might interfere with the test. When the tests were begun, a minimum of five runs was made; more were added, if necessary, until the results of five cycles did not vary by more than 5 per cent from the average.

The results obtained from one brand of zeolite cannot be applied directly to any other brand, or even, usually, to another lot from the same manufacturer. To illustrate, Fig. 1 shows the effect of salt dosage on exchange capacity under identical conditions for

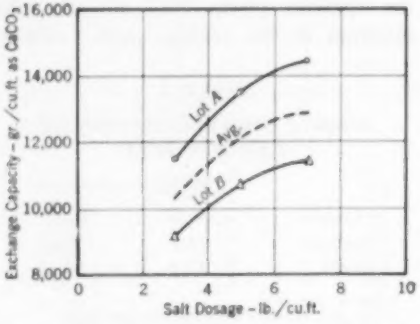


FIG. 1. Salt Dosage and Exchange Capacity (Zeolite)

two different lots of zeolite from the same manufacturer. In one lot the exchange capacity was the maximum that could be expected, while in the other it was lower than is desirable for good operation.

All the polystyrene base resins displayed almost identical results under district conditions, although a slight variation between some lots can be observed. Figure 2 gives laboratory results for the operating exchange characteristics of one polystyrene resin. The one variable that is not taken into consideration here is the rate of brine flow through the unit during regeneration. An examination of Fig. 2 shows that an increase in salt dosage will increase the exchange capacity. Also to be noted is the fact that very good exchange capacities can be obtained at heretofore unattainable salt consumptions. The data in Fig. 2 are not typical for all polystyrene resins because it has sometimes been found that the 10 and 15 per cent brine curves may be superimposed on each other. The 5 per cent brine, however, is always far inferior to 10 per cent.

In plant operation, where 2,000 cu.ft. of polystyrene resin is operated at a

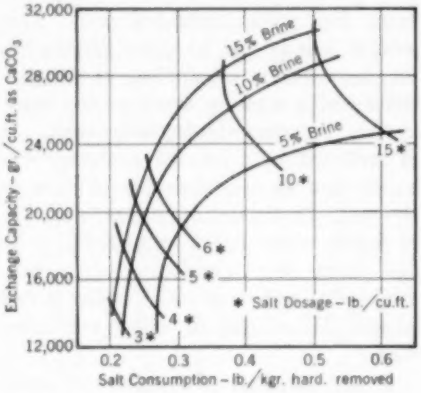


FIG. 2. Effect of Salt Dosage and Brine Concentration (Resin)

regeneration level of 5 lb. per cubic foot, capacities of 23,000 gr. per cubic foot are being obtained after 320 softening cycles (450,000 gal. per cubic foot). Figure 3 shows the results which were obtained from this large-scale upflow softening operation. The difference in exchange capacity shown in Fig. 2 and 3 is due to the direction of water flow during softening. The laboratory results are from downflow while plant data are from upflow operation. This comparison indicates that an increase in capacity of about

15 per cent can be obtained when the flow of water during softening is changed from downflow to upflow, confirming the results found earlier for siliceous zeolites (1).

Brine Contact Time

Conclusive results concerning the effect of the regenerating brine rate of flow on exchange capacity have not been found in the literature. It has been indicated by others that so slow a rate of flow might be attained that the brine could slip by the exchange

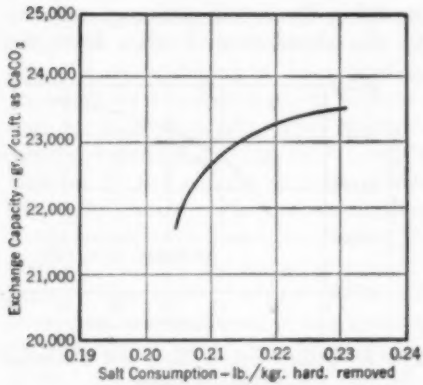


FIG. 3. Salt Consumption and Exchange Capacity (Resin)

material without causing an exchange of ions (3). Conversely, the rate of flow may be so fast that there is not time for the exchange reaction to take place before the brine is removed from the unit by the rinse water. For the siliceous zeolites, a very definite change in the operating exchange capacity takes place as the concentration of the brine is changed from the optimum. Figure 4 shows [1] that brine concentration and brine rate of flow have a decided effect on exchange capacity and [2] that if the rate of brine flow is decreased too much, salt passes through the zeolite without effecting good regeneration. These facts have been noted for all of the siliceous zeolites, but to bring out the point most clearly it should be stated that a total brine contact time of 50–80 minutes (0.5–0.15 gpm. per cubic foot) must be used at the optimum brine concentration.

With the zeolites tested, it has been determined that the optimum brine concentration for new mineral should be about 5–6 per cent at a brine contact time of 20–30 minutes. After the mineral has been used for a consider-

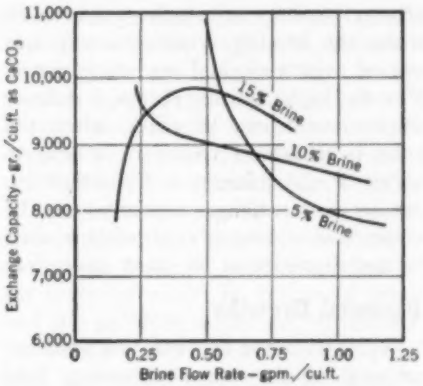


FIG. 4. Effect of Regeneration Brine Concentration and Brine Flow Rate (Zeolite)

able length of time, a greater efficiency of operation can be gained if the concentration of brine is increased slightly. Always, the greater the turbulence of the regenerating solution, the better the exchange reaction will be.

The polystyrene base resins show a greater change in exchange capacity than the zeolites when the rate of brine flow is varied. Here again it might be pointed out that it is almost impossible to discuss one particular variable and follow its effect throughout the exchange reaction without bringing in some of the other very closely related

variables. For example, the exchange reaction during softening for a siliceous zeolite might be taking place over a bed depth of 4–6 in., while for the resin this depth does not appear to be more than ¼–1½ in., depending on flow rate. The rate of flow can be increased to such a point that the breakthrough for the siliceous zeolites becomes very pronounced, whereas the highest rate of flow attainable in the district laboratory (6 gpm. per cubic foot) has produced a very soft water from the resins. Figure 5 shows the variation in downflow operating exchange capacity of a polystyrene resin when the brining (contact time) was varied over a normal operating range. For the high-capacity resins, a definite improvement can be made when the time is increased from 10 or less to about 15–20 minutes. A further increase in exchange capacity can be effected if a longer regeneration time is not detrimental to plant operation.

Bacterial Growths

Recently some concern has been expressed in the water softening field that, because of the organic nature of the new ion exchange materials, the possibility of contamination by bacteria might become a problem. Although it has been reported (4) that bacteria cannot utilize the resinous exchangers for food, this does not necessarily mean that bacteria will not find the ion-exchange beds very good places for habitation. Most bacteria which exist under these conditions are sedentary in nature, attaching themselves to the surface of the granules. Removal of the bacteria during backwash would thus be extremely difficult if not impossible, particularly if the slimes are imbedded beneath the surface of the exchange material. Those bacteria which are filtered out of the water when the units are operated downflow may usually be removed during backwash.

The possibility of the contamination of ion-exchange beds from a water that has been filtered and chlorinated is not very great. The most likely source of contamination would be the regenerating brine. Because of the medium in which the bacteria would have to live, however, it is the opinion of bacteriologists that the presence of pathogens is not to be expected (5). The only harm which might come would be the loss of exchange capacity by the dissolution of silica from the

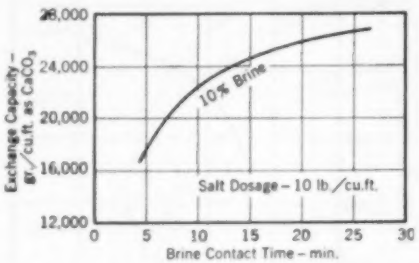


FIG. 5. Brine Contact Time and Exchange Capacity (Resin)

siliceous zeolites, due to local acidity resulting from bacterial action, or a clogging of the ion exchangers by the bacterial slimes. In addition, if a unit became highly contaminated, the bacteria might introduce undesirable tastes and odors into the water.

The siliceous zeolites will not absorb chlorine from the water and disinfection of such units is relatively easy. If the zeolite is clean, the chlorine will pass through the bed virtually unchanged. If, however, the bed has been allowed to become contaminated with bacteria, the chlorine may be used up on passage through the unit. The polystyrene resins, when new, will re-

move small quantities of chlorine from the water. As the soluble materials are leached from the resin, the chlorine demand goes down. In the district laboratories, it has been found that, where the resin is kept sterile, a chlorine residual will be carried essentially unchanged through the bed. The phenolic resins, however, very effectively and continuously remove the chlorine from the water, making disinfection with chlorine extremely difficult. Since the absorption takes place very rapidly, the chlorine may not be carried more than 5–8 in. below the surface of the bed.

After approximately two years of operation, two of the units containing phenolic resins began to lose capacity unusually fast. Examination revealed that in both units the resin was cemented together, leaving only a small channel in the center through which the water passed. Physical separation of the particles followed by backwash resulted only in temporary improvement. Disinfection with formaldehyde proved more effective and was made a regular weekly practice. A return to normal exchange capacity and the absence of further cementing have been observed since the inception of this treatment.

Life Expectancy

It is the opinion of the district staff that it is impossible to predict the true operating life of an ion-exchange material from accelerated tests. Experience has shown that, while a zeolite might stand up for years of service under one set of conditions, it may have a very short life under another. It was for this reason that the ten fully automatic units were installed. Monthly or weekly checks were made on the materials in the units to determine how they were operating. The softening rate of flow was set at 6 gpm. per square foot (2.5 gpm. per cubic foot), a rate which the district has found very satisfactory in plant operation. Because of softener design, it was impossible to exercise exact control over all the variables in the softening and regeneration cycles. Each unit was therefore set to give the best operating conditions possible for the material it contained. The main purpose of this test was to see just what effect the amount of water softened, water quality and chlorine had upon the ion-exchange materials.

When large quantities of water have to be put through ion exchangers, the phenolic and carbonaceous materials do not operate satisfactorily in the presence of chlorine. The chlorine is absorbed causing a breakdown, which manifests itself in color-throw and a rather rapid loss of exchange material. Where relatively small amounts of water are softened, the breakdown which may come from the oxidizing effect of the chlorine would be relatively small and the problem would not be serious. In waters where chlorine is not present, the carbonaceous and phenolic resins have given years of satisfactory service. Under some conditions, their ability to remove chlorine is a desirable feature. When an objectionable taste in water is due to free chlorine, it can be removed very easily by passage through one of the phenolic resins, but chlorinous tastes which arise from the reaction of chlorine with phenolic wastes will pass through the unit unabsorbed.

Recently portions of the siliceous zeolite and polystyrene resin which had passed the greatest amount of water per cubic foot were sampled for test purposes. New material corresponding to each of these specimens was also sampled so that parallel tests could be

made. Sieve analyses for both the new and used materials have been given in Table 3. The siliceous zeolite sample started with an exchange capactity of 10,000 gr. per cubic foot when new. The exchange capacity dropped slowly until at present (after passing 2 mil. gal. of water per cubic foot) a 35 per cent loss is indicated. It was felt that this loss might be directly related to the weight loss, but this theory did not prove entirely correct as only a 26 per cent loss in weight has been found. Perhaps other factors, such as a partial collapse of the particle structure due to the silica dissolution, or possibly a clogging of the zeolite particles by bacteria or some foreign matter like colloidal alumina or calcium carbonate, may have been partly responsible for the loss in capacity. In direct contrast to the siliceous zeolites, the polystyrene resins show no loss in exchange capacity or unit weight. It appears that the siliceous zeolites would have to be replaced after about 2 mil.gal. had been softened per cubic foot. The styrene resin, on the other hand, seems to be as good at present as when it was first put into operation. The hydraulic characteristics of the material have shown marked improvement. The loss in fines has amounted to slightly less than 3 per cent, and the total loss of resin since the start of the test has been 3.2 per cent.

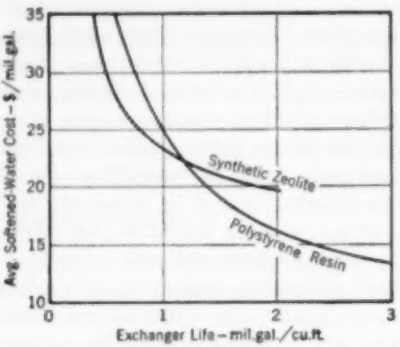


FIG. 6. Life Expectancy and Softening Cost

Economic Considerations

Early in 1947 studies (*2*) were initiated by the district to determine which of the cation exchangers—the zeolites or the polystyrene resins—could be operated more economically over long periods. At that time the only data available on salt consumption under salt semistarvation conditions were from laboratory test columns operated downflow. After that study was made, 2,000 cu.ft. of resin was placed in one of the district softening plant upflow units. This unit showed a 15 per cent higher exchange capacity and a slightly lower salt consumption than the test unit with the same resin, due primarily to the greater efficiency of upflow operation.

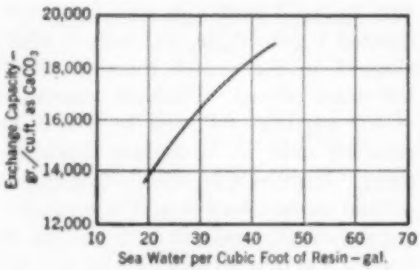


FIG. 7. Sea Water Regeneration and Operating Exchange Capacity (Resin)

A recent economic study, comparing the polystyrene resin in the plant unit with the average of the zeolites used in softening plant operation, provided the data shown in Fig. 6. The following items were given consideration: [1] cost of exchange material; [2] cost of salt for regeneration; [3] cost of sodium silicate addition where required;

and [4] value of the regeneration water lost. The unit charges for these items are listed in Table 5. Although an appreciable saving in construction cost can be effected if a plant is designed on the basis of the higher exchange capacity of the polystyrene resins, no allowance was made in Fig. 6 for this factor because the resin will be installed in units already constructed. From the curves in Fig. 6, it can be seen that, for most municipal or other large installations, the savings in operation may

TABLE 5

Basis of Softening Cost Comparisons

	Zeolite	Resin
Cost per cu.ft. delivered —$	7.08	16.55
Exchange capacity— *gr./cu.ft.*	8,700	23,000
Salt efficiency per kilograin hardness—*lb.*	0.37	0.22
Silica addition (SiO_2)— *ppm.*	7	0
Life expectancy— *mil.gal./cu.ft.*	2	3
Cost of salt per ton—$		4.45
Cost of sodium silicate per ton—$		20.00
Value of regeneration water per mil.gal.—$		58.30
Cost of waste disposal per mil.gal.—$		1.00
Average hardness removed—*ppm.*		265
Rinse water required per regeneration —*gal./cu.ft.*		15

offset the higher initial cost of the resinous exchangers.

Another series of tests made in the district laboratory is of economic interest where sea water can be utilized for regeneration of the styrene resins. It was found that, when a brine contact time of 25 minutes was employed, the exchange capacity of the resin was almost directly proportional to the amount of sea water used (*see* Table 6 and Fig. 7). An exchange capacity of 14,000 to over 18,000 gr. per cubic foot was obtained when 20–40 gal. of sea water was used per cubic foot of resin. This amount corresponds to about 4.25–8.5 lb. of salt. Although the exchange capacity was not as great as that obtained when a pure sodium chloride brine is used, sea water regeneration can effect greater economy in operation if a plant is favorably located near the ocean shore.

Summary

Under Metropolitan Water Dist. operating conditions with pretreated Colorado River water, the behavior of the several types of cation exchangers tested may be summarized as follows:

TABLE 6

Analysis of Pacific Ocean Water

Constituent	Amount *ppm.*
Silica (SiO_2)	0.7
Calcium (Ca)	390
Magnesium (Mg)	1,240
Sodium and Potassium (Na, K)	10,300
Carbonate (CO_3)	0
Bicarbonate (HCO_3)	142
Sulfate (SO_4)	2,570
Chloride (Cl)	18,300
Total dissolved solids	32,870
Hydrogen ion concentration (pH)	7.8
Hydrometer (sp.gr.)	1.0250

1. Because of silica dissolution and attrition, the siliceous zeolites lose material continuously, causing depletion of the volume in the softener unit. The rate of loss is very slow initially but increases markedly as the zeolite ages. At the same time the exchange capacity of the zeolite remaining drops steadily and the salt consumption increases. The useful life of the material has been found to be about 2 mil.gal. per cubic foot of zeolite.

2. The carbonaceous exchangers maintain their capacity quite well with continued use and the loss of material is not excessive if the upflow rate is

adjusted to meet the requirements of the material. The fine particle size of these materials, however, results in excessive loss of exchanger at normal upflow softening rates. With intermittent use, the carbonaceous exchangers are subject to excessive color-throw for a time after resumption of operation. Since chlorine is effective in sterilizing only the top few inches of a unit containing carbonaceous exchange material, bacteria may grow in the lower portion of the softener.

3. The phenolic resins are oxidized by the chlorine in the softener influent water, causing disintegration of the surface of the particles and loss by carryover. Volume depletion is quite pronounced. The exchange capacity of the material remaining apparently is unaffected by use, but the capacity of the softener unit as a whole may be appreciably reduced if measures are not taken to inhibit bacterial slimes which otherwise cement the exchange material and cause serious channeling. The absorption of chlorine by the phenolic resins may permit bacterial growths to develop below the sterilized zone.

4. The polystyrene resins maintain their normal characteristics under operating conditions which heretofore have caused the siliceous zeolites to lose capacity. From results to date, it appears that a minimum useful life of 3 mil.gal. per cubic foot may be expected from these materials. They are essentially unaffected by chlorine in the softener influent water. Finally, their ability to operate under salt semistarvation conditions without apparent deleterious effect on the resin or on the quality of the softened water makes the outlook very promising for the use of these exchangers where economy of operation and a long useful life are factors of primary importance.

Acknowledgment

The authors wish to acknowledge the cooperation received from members of the laboratory staff of the district who have contributed ideas and data to these investigations. Metropolitan Water Dist. operation is under the direction of Julian Hinds, Gen. Mgr. and Chief Engr. The chief operations and maintenance engineer is Robert B. Diemer. These research investigations and the water softening and filtration plant are under the supervision of William W. Aultman, Water Purification Engr.

References

1. Streicher, L.; Pearson, H. E. & Bowers, A. E. Operating Characteristics of Synthetic Siliceous Zeolite. Jour. A.W.W.A., **39**:1133 (Nov. 1947).
2. Aultman, W. W. & Bowers, A. E. Use of Organic Cation Exchangers for Municipal Water Softening. Proc. 9th Ann. Water Conf., Eng. Soc. of Western Pa. (1948).
3. Walton, H. F. Ion Exchange Between Solids and Solutions. Jour. Franklin. Inst., **232**:4:305 (1941).
4. Cruickshank, G. A. & Braithwaite, D. G. Sterilization of Cation Exchange Resins. Ind. Eng. Chem., **41**:472 (1949).
5. Klumb, G. H.; Marks, H. C. & Wilson, C. Control of Bacterial Reproduction in Cation-Exchange Layers. Jour. A.W.W.A., **41**:933 (Oct. 1949).
6. Bauman, W. C.; Skidmore, J. R. & Osmun, R. H. Dowex 50—A New High-Capacity Cation-Exchange Resin. Ind. Eng. Chem., **40**:1350 (1948).
7. Myers, R. J. & Eastes, J. W. Synthetic-Resin Ion Exchangers in Water Purification. Ind. Eng. Chem., **33**:1203 (1941).
8. Thompson, J. & McGarvey, F. X. Some Practical Aspects of De-ionization. Proc. 8th Ann. Water Conf., Eng. Soc. of Western Pa. (1947).

The Value of Standards to the Water Works Industry

By Harry E. Jordan

A statement prepared by Harry E. Jordan, Secy., American Water Works Assn., New York.

THE development and wide acceptance of voluntarily developed civilian standards for engineering materials is recognized internationally as an important factor in the industrial and economic progress of the United States.

Although the American Standards Association (under another name) was not established until World War I, standards for industrial and construction components, developed through the free exchange of information among civilian producers and consumers, have been rapidly growing in numbers and general acceptance for more than half a century.

Without reference to the dictionary, the term "standard" will first be considered to mean "a statement which, in terms of quality or dimensions or both, describes an engineering material." Such statements must be based upon a consensus arrived at by competent and objectively minded persons.

Explanation of Terms

A standard may also describe, in terms as exact as conditions permit, methods of examination or analysis, methods of installation, methods of use or methods of reconditioning materials. Such standards are frequently referred to as procedural documents or manuals of practice. They require for their development and acceptance, agreement among competent and objectively minded persons.

Such standards, manuals, procedural documents and the like, when developed by an organization such as the A.W.W.A., must be considered as recommendations of dimensions, quality or performance—to producers as well as consumers, or users—that members of either group may individually elect to use or not as they see fit. Their use is not mandatory among members of an association and cannot be so considered without being in violation of the antitrust laws of the United States. But, when a consumer issues a contract or purchase proposal which makes proper reference to such a standard, and a manufacturer or a contractor enters into an agreement to furnish goods or perform services according to the terms of the standard to which reference is made, it becomes the legal obligation of the manufacturer or contractor to produce material or render services according to such terms; and it becomes the obligation of the purchaser or owner to accept materials or services furnished or rendered in compliance with the terms of the standard. These distinctions are important. They may be epitomized by stating that "an association standard is not a mandatory standard until and unless it has become the basis of a contractual relationship between producer and consumer."

Governmental agencies promulgate standards which are mandatory—to the extent that the agency promulgat-

ing them has authority. Governmental standards are not under discussion here.

Civilian standards are considered legal when they: [1] promote efficiency in production; [2] eliminate misrepresentation; [3] provide adequate information concerning materials; or [4] improve the service rendered by the use of standardized items. They are considered illegal when they restrain competition or involve price fixing. Compulsory use of an association's standards by its members cannot be a condition for membership. In other words, a "closed shop," with standards as the criterion, is not permissible.

It must be considered, however, that the word "competition" implies the ability of the vendor or producer to render competent and adequate service. No standard is worth the paper used to print it if it does not exclude incompetently made and inadequate materials. This point is so obvious that it will not be pressed.

Historical Development

This Association was organized in March 1881, with its first program made up largely of informal discussions. At the second meeting (1882) a Committee on Records was formed. The descriptions of that committee's work clearly indicate that it was the first step in the long history of associated thinking among water works engineers designed to simplify and improve the production of water works components and to assure the user and the public that good service would be obtained from the use of standardized materials. The formal report of the Records Committee was presented to and approved by the members present at the fifth (1885) meeting.

In the proceedings of the fourth and fifth annual meetings, reports were made concerning a material known as "Kalamein," which was being actively promoted for use as a water distribution pipe. During the then rapid increase of water systems in cities and towns, it was being widely sold as a cheaper but presumably long-lived product. Kalamein pipe was said to be made of wrought iron, coated (presumably alloyed) with zinc, lead, nickel and tin. The nonferrous metals made up about 13 per cent of the total metal. After the iron pipe had been dipped in the molten coating metals, it was dipped in a hot asphalt bath. (It is important to record that this so-called wrought-iron pipe cannot be considered in the class of modern wrought iron. Sixty-five years have brought about many changes in the quality of cast iron, wrought iron and steel, and it would be dangerous to base opinions of present materials upon what was produced in 1885.)

A special committee to investigate the pipe reported in 1885: "Your Committee would express grave doubts as to its [Kalamein pipe's] fitness for the purposes for which it claims a place in the construction of permanent water works." Much of the time of the convention was taken up by a pro-and-con discussion of the merits of this now generally forgotten material. This early committee, which in its fashion was the forerunner of the present A.W.W.A. Committee on Water Works Practice, served its day and the industry well. Kalamein pipe was not suitable as a construction material for water works. Time has rendered the final judgment. Kalamein pipe is no longer manufactured and few in the field even remember it.

Also at the fifth annual meeting (1885), a paper, prepared at the request of the officers of the A.W.W.A., by Phineas Ball of Worcester, Mass., discussed the proper thickness of cast-iron pipe to withstand various operating pressures and water hammer, and to provide "security from breakage in handling."

In 1886 "in lieu of the report of the Committee on Standard Specifications for Cast-Iron Pipe," G. W. Pearsons, of Kansas City, discussed "uneven castings, pipe weight, lead room and how to get good pipe."

At the ninth meeting (1889), S. B. Russell, of St. Louis, outlined the plan and scope of pipe standards, and in 1890 reported for the committee. The report consisted of one page of text and a one-page tabulation of dimensions and weights for Class *A*, *B* and *C* pipe—3-in. up to and including 48-in. diameter. In 1891 a further report was made which established a series of test bar and pressure requirements.

Thus has been outlined the development of A.W.W.A.'s first "standard" for a construction material. The A.W.W.A. is seen, in the first ten years of its history, setting up a procedural document on records, developing a set of dimensional and quality standards for cast-iron pipe, and accepting the report of a committee which investigated and condemned an inferior grade of distribution pipe.

In 1908 the A.W.W.A. and the N.E.W.W.A. joined in the acceptance of a new set of cast-iron pipe standards. These were supplanted by the 1939 A.S.A. standards for pit-cast pipe, which are now being extended to include A.S.A. standards for centrifugal pipe.

The various steps toward today's standards for cast-iron pipe have been followed through primarily to show that the A.W.W.A., very, very early in its history, turned toward standardization; and also to show that the propriety of revision to keep up with metallurgical progress has been freely recognized.

No more important step in the A.W.W.A.'s technical progress was ever made than the creation of the "Standardization Council" in 1920, with George W. Fuller as the prime mover in the action and first chairman of the council. Malcolm Pirnie succeeded Fuller as chairman of the council (now the Committee on Water Works Practice) in 1928 and was in turn succeeded in 1947 by Louis R. Howson, who continues ably to direct this work. The Association has been fortunate in the leadership exercised by these three men.

The importance of the organization of the Council on Standardization rested in the fact that its primary function was that of deciding whether or not to develop a standard. Prior to that time no general guidance had been given to standardization policies, and committees were set up without adequate planning.

The decision not to standardize is often more important than a decision to set up a standard. Standardization of water works construction components is not now undertaken until the materials have been used for a sufficient length of time to demonstrate their basic value. Such materials must be freely competitive and at least nationally available. Materials or processes which are held under noncompetitive patent control are not standardized. The growing area of standardization

gives promise of presenting some difficult decisions in the future relating to standardization or appraisal of the performance of equipment or processes competitively available but controlled by patents.

Benefits of Standardization

How has standardization benefited the water works industry? Perhaps the best expression of the purposes of an association such as this one is found in the words of Abel Wolman in his 1930 report as chairman of the A.P.H.A. Committee on Research and Standards. In that report, Wolman said:

> A member of an association of national scope may justly expect it to perform for him two major functions. It should provide for him an opportunity for exchange of information with fellow workers, and *it should formulate standards of measurement in those fields where a uniform procedure would facilitate efficient action.*

What matters are properly considered for standardization? All will agree that the widely used construction components are such. Almost to the same extent, the methods of installation of basic materials are the subject of coordinated study and standardization. When the maintenance of certain types or classes of existing installations becomes recognized as an industry-wide problem, the most acceptable and effective procedure can be recorded in a recommended-practice document. Finally, it is now recognized that there is a growing tendency to develop procedural documents covering routine operations or even customer and public contacts.

Between the standardization of basic materials and the procedural recommendations that relate to customer contacts there is a wide difference, involving a shift from the tangible to the intangible, from materials susceptible to exact measurement or appraisal to procedures which can only be approximately appraised by the general attitudes of the customers toward the utility. It is obviously far easier to reach a consensus concerning a material such as pipe than it is to reach a common viewpoint concerning the method of installing it, and it is harder still to agree upon the best procedure to disinfect it, or when and how to make an inspection of it after it has been in service for a term of years.

It has been wisely observed that standardization can tend to freeze practice. In other words, if there is too complacent an acceptance of a standard, there is danger that improvements in materials will not be sought or accepted, and this danger is greater when the standard covers procedures. The recognition of this danger is a brake upon precipitate ventures into areas of procedural standardization. It was the recognition of this fact that led A.W.W.A.'s Board of Directors to record so frankly with the U.S. Public Health Service its opinion that the latter's "Manual of Recommended Water Sanitation Practice" be released not as a standard nor as an official pronouncement, but as a simple record of opinions of a select committee of service personnel.

The water works industry in continental North America is made up of approximately 20,000 units which serve population groups ranging from a hundred persons to the millions who dwell in New York or the other great metropolitan centers. In any one of these properties, whether it be serving a hundred or a million persons, ma-

terials to build the distribution system can be puchased under A.W.W.A. standards. There are, in many of these properties, men in charge who have not had the opportunity to study engineering materials and who are unable, on their own behalf, to describe in accurate and adequate terms what they consider to be needed for the plant they operate. But confusion equal to the Tower of Babel would result if even 10 per cent of the water works properties insisted upon standards of their own.

Thus the Association, through its years of study, evaluation and standardization of the primary materials used in water works construction, has met two important, but somewhat opposite, needs. It has, through the release of minimum standards for pipe, valves, hydrants, meters and so forth, provided the local water works executive with a set of yardsticks for him to apply to his purchases. It has assured him that a member manufacturer will in good faith provide material in accordance with those standards when he is asked to do so.

At the opposite point, the Association standards have reduced the number of special requirements which manufacturers may be called upon to meet. This in itself is an important factor, for multiplicity of design standards is a costly luxury. Conformance to basic standards is the greatest economy to the manufacturer, the engineer and the customer.

The fact that the A.W.W.A. provides an international meeting place for water works men to exchange ideas and increase their competency is a primary reason why the Association merits the participation of every man who considers himself a part of the water works industry.

Through the years of past performance and the advance of the Association into increasing activity in the standardization of the industry's materials, it has rendered and will continue to render to the industry and to the public a service of fundamental value, a service which no local or regional association can render with adequate authority and a service which is completely consistent with the American habit of reasoning together and developing an accord in political and economic, as well as engineering, matters.

What the State Health Department Expects From Licensed Water Works Operators

By John M. Hepler

A talk presented on Sept. 28, 1949, at the Michigan Section Meeting, Traverse City, Mich., by John M. Hepler, Director, Div. of Eng., State Dept. of Health, Lansing, Mich.

BEFORE we talk about the operator, I think we should say a few words about the health department and some of its primary responsibilities. Sometimes we forget the fundamental purpose of the health department. Primarily, it is charged with the overall duty of preventing disease, especially disease that kills. To accomplish this duty, the department requires a great many specially trained people—doctors, nurses, engineers, sanitarians, laboratory and X-ray technicians, dentists, statisticians and others. In the early days the concern of these people was the prevention of contagious diseases. As a department, we worried about smallpox, diphtheria, scarlet fever, typhoid fever, whooping cough, mumps and measles. In the engineering division, our biggest concern was waterborne typhoid fever. One of my early and important duties was to visit typhoid fever patients to see if by any chance we could prove that it was not a public water supply that caused the outbreak. Another important duty was to get chlorination equipment established on the municipal supply. And right there is where the water works operator became a public health worker. The health department started to make you fellows realize that you had an important job to do, and that job was to maintain chlorination treatment without interruption every minute of every day in the year to prevent fatal disease.

Naturally, others worked on these problems as well as the water works operator and the engineer in the health department. Vaccines, antitoxins and serums were developed, and many communicable diseases have now become insignificant in our lives. Today the leading causes of death, and the ones which are worrying the health departments, are the diseases of old age—heart disease, cancer, nephritis and so on. That reminds me of a suggestion which the Director of the Disease Control Division made—if any of you are worrying about dying of cancer or heart disease, go back to the old system and get yourself a good case of typhoid fever and you won't have to worry about the heart or the cancerous condition. In former times the life expectancy was only about 50 years, whereas today it is nearly 70 and we must expect the diseases of old age rather than the diseases of youth or middle age to cut us down.

It might be mentioned at this point, also, that, as new duties or new methods of attacking disease appeared, reorganization of the attacking forces had to be made. You will remember that back in the 1920's Bill Hirn looked after water plants, while in the 1930's both Ray Faust and I were assigned to that

work because, as more plants were built and more problems arose, more men were needed. It was in that period, also, that we started establishing the county and district health departments which provided public health engineers and sanitarians to assist us in our sanitation work. In the 1940's it became necessary to create a division or section which gave its entire time to water and problems connected with it. We also enlisted the services of the county health department sanitation personnel for obtaining samples on the distribution system as a check against contamination from back siphonage and cross connections.

Environmental Sanitation

As previously indicated, the function of the state health department is to coordinate and direct all of the activities of all agencies which are working for the improvement of health. The function of any division of the department is to do that part of the job for which it is best fitted. Consequently, in the division of engineering, our activities are related to those things which have an engineering aspect—chiefly environmental sanitation.

I wonder if you appreciate how much that term "environmental sanitation" really includes. When you look at the activities of a health department, there are two well defined fields of work. In one, the activity deals entirely with the individual. It involves the functions of the doctors, the nurses and similar professions. In the other field, there is the problem of getting everything around the individual in such condition that it will not harm him. This includes water supply, sewage, garbage and refuse disposal, air pollution, the effects of insects and rodents, housing, ventilation, lighting and all the other conditions around us which might affect our health. As you study that list, you will see that almost always engineering is involved.

Since water is one of the items in environmental sanitation, it becomes the division of engineering's duty to coordinate and direct the activities related to supplying a potable, palatable, safe-to-drink, safe-to-swim-in, safe-to-use water supply. And that brings us to you fellows—the operators of water plants.

From the health department's viewpoint, you are a health worker in a specialized field. Your main job is to safeguard health as far as water is concerned. From the standpoint of your job, you are in a peculiar position, for you have two bosses—the city officials and the state health department. There were times when that condition created awkward situations. Certification has corrected a great deal of the difficulty, however. Today technical control rests with the operator, and the methods and effectiveness of control are the concern of the state health department. Policies and fundamental procedures have to be discussed with the city officials.

Need for Coordination

Just as the state tries to coordinate the work of all agencies in the public health field, so we would like to see all of the agencies interested in water coordinate their activities. We would like to see cooperation and close liaison with the public works department, the local health department, if there is one, the county or district health department, and the building, plumbing, fire and any other department that in one way or another has some function related to the handling of the water you are producing.

I do not mean that either the operator or the representatives of any of the other departments which I have mentioned has to be the "boss," but there should be close liaison between you and those departments, and it should be well understood that you have the right and the privilege to ask questions and to be interested in the things they do which might affect the quality of the water you are producing. Conversely, they should know where to turn for the type of help which you can give. In other words, in my opinion, the licensed operator has not only a plant to run and a product to furnish but also the responsibility of seeing that others whose job involves handling or working with his product do not spoil it or destroy its quality. Very definitely the day is past when the operator's interest ends at the pump discharge.

Not long ago the U.S. Public Health Service brought out a proposed standard in which it tried to demonstrate that the water department's interest extended to the consumer's faucet. The principle was sound, but there were very definite legal objections. There is no reason, however, to take a defeatist attitude because the water department cannot exercise jurisdiction up to the consumer's faucet. There are other ways in which this objective can be accomplished. With proper liaison, the plumbing or building department can handle the situation within the private home or building and see that your product is not ruined at that point, provided, of course, they know what you want and what they should look for and require.

What you should be doing, in addition to producing a safe and adequate water supply, is to keep informed on where and how mains are being installed; where new commercial and industrial users are being connected; what old as well as new commercial and industrial users are doing with water; what private supplies are connected to your system; what treatment for commercial uses is being given to your supply after it leaves your plant; and whether another municipal department or an industry is taking action which might change the quantity or quality of the supply.

To do these things, you first must have an understanding of the total problem; second, you must inject your interest into the water picture; and third, you must develop the idea of cooperation so that you can get assistance from the other agencies. You certainly cannot expect to get all this information or do all these things yourself.

Local Health Officers

A question arises concerning the place of the county or district health department engineer or sanitarian in this water picture. Primarily, his interest is in the quality of the water as the consumer gets it. His interest is not one of process or treatment; in fact, we have told him to leave that phase of the water supply alone. We have specifically said that, for the time at least, he should know in a general way the processes that are being used in the treatment plant, but he is not supposed to come into the plant and tell you to add more chlorine because he has had a few bad tests, or to reduce it because he has had an odor or taste complaint, or to make any other suggestions of a strictly technical nature. His interest is in the delivery system, in the quality of the water in the mains. Since the U.S. Public Health Service "Drinking Water Standards" recommend a specific number of samples to be taken

from the distribution system, it has been suggested that the local health department officer collect those samples or supplement the number of samples which you are collecting as a check and as a means of discovering things happening on the distribution system which you might otherwise never hear about. If he gets bad samples, it is his duty to question why they are bad and to try, with your cooperation, to get the trouble corrected.

If he renders service in a municipality which does not have a public water supply, his duty is to try to get it. He is expected to promote interest in and construction of a public water supply. In the meantime his interest lies in the private supplies which are distributed to the individual homes, mercantile establishments and, particularly, the places where people are employed or served. This means that he has a very close relationship with both well drillers and plumbers. He is a fellow whom you should know well and be on friendly terms with, as his presence in the community gives you another method of approach to the problem you might want to solve.

Similarly, the local health officer has a rather close relationship with the public as individuals and with public officials. Some of the latter may be your employers. The health officer may even be the means for you to obtain a back-door entrance when you cannot get in through the front. One of his important duties has been to get the public thinking in terms of water quality. He will take a sample for anybody, send it to the laboratory for analysis and report the results to the individual. If the sample is from a well supply and the test result is unsatisfactory, the health officer will make a point of calling on the owner of that supply and offering suggestions for its correction and improvement. When it comes time to promote a public supply or when it may be necessary to have some assistance in explaining a condition in your water supply, who would be a better man to call upon for help than the county or district health department engineer or sanitarian?

Should water works operators make analyses for individuals who bring samples to the plant? Primarily, that is a question of policy. If the policy is simply based on currying favor with a voter, however, it is worthless. If you feel that the analysis may help to improve a bad situation in a part of the town where your supply has not as yet been delivered, it can be good policy. I believe, however, that, if it is done, it at least should be done in conformity with the plan and procedure recommended by the state health department. Remember that when you have completed the test you are only telling the individual what the quality of the water was at the time he took the sample. If the water contained disease organisms, the individual would know it long before you told him. For this reason, we feel that running a sample is of very little value unless you can render a service in connection with the reporting of the analysis. A portion of the public still needs to learn that a "safe" report does not mean that the supply is safe henceforth and forevermore, but only that it was safe at the moment the sample was taken and that, unless other conditions related to the supply are right, it can become an unsafe supply at any time.

Obligations of Operators

These are some of the responsibilities which I believe rest upon your

shoulders. These are some of the things we would like to see you do. I cannot believe that, when you obtain your operator's certificate and take over the operation of a treatment plant, you are fulfilling the obligations either to yourself or to your employer if you just settle down to running a plant and make no effort to improve your position. And when I say "improve your position," I do not mean needle the city fathers occasionally to raise your salary a few hundred dollars a year. You are holding down a responsible position in the city government. You are responsible for the health of the people as related to their water supply. You have the obligation not only to keep faith with those who employ you and with those who are supervising your work but often, particularly in small towns, you have the obligation to show your worth as well. Many small towns need improved management in their water works departments. They need better bookkeeping, better meter maintenance, better supervision of service connections and main laying. As a member of this Association, you have access to the best reference and educational material that is available in the water works field. If you are not using that information and are not showing in various ways that you have the qualifications for a more important place in the water department, you are dead on your feet already. I could point out one man in this room right now who had neither a college education nor a good working knowledge of chemistry or bacteriology, but who did have an idea. Today he not only operates the water plant but is what you might call the manager and the superintendent of the water department. He supervises the installation of main extensions and the making of house service connections. He issues the water bills and collects the money paid. He is the purchasing agent for the water department. That man has made himself an important individual in the community. He has not had to move out of the community to improve his condition, financially or otherwise. There are others in this room who could do the same thing.

What I have said so far is not a complete catalog of all the things which a health department expects from a licensed operator, but I believe that you will have a pretty good idea of what we expect from each one of you, regardless of the official title of your position. To sum it up, I might express it this way: We expect you to be more than just an operator. We expect you to be a public health "official." We expect you to be a consultant or adviser to other departments exercising authority in the delivery or use of your supply. We expect you to be an important individual in your community and one whom the public will look upon as so important to the protection of their health and their financial investment in the system that, even though a new administration comes into office, it will not risk firing you, because it knows the public would not stand for it. We have several men in this organization who have already attained that stature in their communities. To the others I would say, "Go, and do likewise."

The State Board of Health and Public Water Supplies

By Arthur N. Beck

A paper presented on Oct. 20, 1949, at the Alabama-Mississippi Section Meeting, Jackson, Miss., by Arthur N. Beck, Chief San. Engr. & Director, Bureau of Sanitation, State Health Dept., Montgomery, Ala.

IN 1914, when the Bureau of Sanitation of the Alabama Health Dept. was organized, outbreaks of typhoid fever in towns and cities of the state were an annual occurrence and were accepted more or less as a matter of course. From 1914 until about 1924 the work of the bureau's engineers was no easy task. They were, in general, given little consideration and cooperation, possibly because of reluctance to accept new ideas and also doubt of the need of sanitary measures. A selling job had to be accomplished so that water works management and the bureau could work together to a common end. During the formative period of the bureau, definite policies were established which have been carried through to the present day. The soundness of these policies has been proved, as manifested by the genial feeling that exists between men in the two fields of operations, so widely different and yet so closely related.

Early in the program of water works control by the health department, its limitations were fully realized and yet the responsibilities could not be overlooked. Engineers having a background in water supply and a knowledge of the fundamentals of sanitation were chosen to work on water supply control. They contacted water works officials and offered every aid possible in solving the many problems that existed. The program was advisory rather than regulatory. Improvements to water supplies came, at first, at a slower rate perhaps than if other methods had been employed, but a feeling of confidence was gained by proceeding along the lines of offering constructive aid. This practice has worked to the advantage of both the health department and the operator and ultimately of the people served.

Operators' Responsibilities

The production of a safe water for human consumption is a responsibility of the community and one that is definitely a public health activity. Primarily, the water works operator is responsible for the production and the delivery of a safe and wholesome water at all times. The nature of his service places the water works operator in an entirely different category from other community employees, for the entire community is dependent upon him for health and happiness. Should he fail to live up to these responsibilities, disaster may result. Throughout his career, the water works man, whether he is a shift operator or a utility manager, is morally obligated and duty bound to deliver a quality product.

The construction and operation of water works are expensive. A mass of equipment must necessarily be incorporated in the plants and a considerable number of workers must be employed to produce desired results. Equipment should be operated in a manner consistent with the end-product desired or the end-product obtainable. It is the duty of water works management to operate each piece of equipment in the most efficient way and to maintain all parts of the water works to assure long life and good service.

The keeping of proper and adequate records is a most important function of water works management. No business can be efficient unless its books are in order. The water utility is no exception, for without question it is business, and big business. There are times when revisions of rate structures are necessary, plant expansions are needed and new equipment is essential. In all instances, adequate and up-to-date records are of prime importance.

The many ramifications of water works management and operation classify the work as a profession rather than as a skill or trade. A profession carries with it both individual and collective responsibilities. If these responsibilities are accepted, those engaged in the field must become fully informed regarding all phases of each particular operation. It is the duty of water works personnel to keep abreast of the times and be ever on the alert to adopt new ideas and developments for better service to the community.

A great deal has appeared in the literature of the past few years regarding public relations. The responsibilities for this activity should not be passed over too lightly. Water works men are prone to bury themselves in their work, forgetting to keep the public apprised of their activities, problems and services rendered. A good public relations program will undoubtedly pay dividends.

Health Department Functions

The relationship between the health department and water works management must, of necessity, be one of complete understanding in order that the common goal of the continued production of an adequate and safe water may be achieved. It must be remembered that the sole responsibility of the health department, legally and morally, is to insure the production and delivery of a reasonably safe and adequate supply of water at all times. To achieve an objective, particularly one planned over an extended length of time, it is essential that rules be adopted and adhered to, whether by law or by regulations of the responsible organization. It is under these laws and regulations that health departments must operate.

In Alabama, the state board of health is charged by legislative act with general supervision and control over all public water supplies and water works in the state, in so far as purity, potability, wholesomeness and physical quality are concerned. This responsibility is met by the inspection of water supplies at regular intervals and by working very closely with the water works officials to insure a wholesome and high-quality product. Inspection of water works facilities and consultation with the authorities lead also to securing necessary improvements.

Bacteriological examination of water samples for coliform organisms is the accepted method at present for determining whether a water is safe. In

some states, the health department collects samples from each of the public water supplies for bacteriological analysis. In Alabama, however, the responsibility for collecting samples and delivering them to the laboratory of the state board of health rests on the owners of the public supply Samples from each supply are requested monthly as a minimum. These are collected from the treatment plants as well as at points on the distribution system. In the early days of public water supply control, very little attention was given to the water after it had left the plant. Entire distribution systems have been installed and main extensions have frequently been made without giving thought to cleaning the barrel and adequately disinfecting the inside surface of the pipe before placing it in service. It is agreed that water works officials should concern themselves with the quality of the water delivered to the consumer's tap and not merely with the quality of the water as it leaves the plant. It is the recommendation of the state health department that all mains be adequately chlorinated in accordance with A.W.W.A. standard procedures before being placed in service. In the author's opinion, bacteriological analyses of samples at representative points on the distribution system should be made before offering the water to the consumers.

As part of the control of public water supplies, the Alabama State Board of Health is charged with the duty of inspecting proposed sites for water supply development and checking plans and specifications of new water works facilities, as well as of proposed water works improvements. This activity is necessary if the engineers of the health department are to safeguard properly the water supplies and the communities which they serve. The department engineers must be kept fully informed of any changes made in a supply so that correlations may be established between the physical equipment and the sanitary quality of the water produced. Plans and specifications submitted to the department are checked as to layouts and equipment involved, but not structurally. These engineers are in a position to give constructive advice to the water works personnel as well as to the consulting engineer engaged in the actual design and construction.

Permit Requirements

Before any water supply in Alabama can be used to furnish water for the public, a permit must be obtained from the state board of health. Prior to issuing a permit for operating a public water supply, the state health department has the duty to determine, as a fact, that the water being supplied or to be supplied is such that, under all circumstances and conditions, it is pure, wholesome and potable and does not endanger the life or health of human beings. The permits are revocable or subject to suspension by the board at any time it shall determine that the water being supplied is, or is in danger of becoming, unable to meet these qualifications. This charge placed upon the state health department by the people of Alabama is a grave responsibility and one that has been accepted conscientiously during the past years.

The act setting forth the responsibilities of the Alabama Board of Health also includes, among other items, methods of proceeding against owners of public water supplies who

violate its provisions. Although the water law has been a part of the Alabama code for many years, it has never been invoked by the state board of health. It has always been the policy of the health department engineers to work very closely with the responsible officials of public water supplies in order to secure needed improvements and corrections, particularly where the community health was endangered. Persuasive methods are used rather than legal citations. Reports of inspection of public water supplies by the department's engineers carry recommendations for improvements. These recommendations become an order only when it is sincerely felt that the corrections are absolutely needed for the protection of the people's health and all other methods have been exhausted.

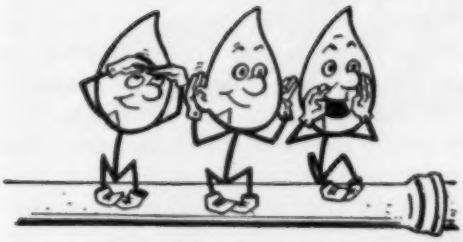
Record of Achievement

Having spoken of responsibilities, it is appropriate to examine the record of achievement. Typhoid fever statistics provide a good example. The typhoid rate was about 38 per 100,000 in 1917, with a total of 895 deaths. Today the typhoid rate is about 0.2 per 100,000, with 6 deaths. The 314 public water systems, together with sewerage and pit privy installations, serving one-half of the state's population cannot claim all the credit for this phenomenal reduction, but they have played their part. It is gratifying to know that not one single case of typhoid fever has been traced to a public water supply in Alabama since 1923, over a quarter of a century. The growth of public water supplies in the smaller communities unquestionably has played a large part in the reduction of this dread disease.

There is no doubt that operators of public water supplies have done an excellent job. Their conscientiousness and willingness to receive new ideas and methods, and the cooperation of government officials, have been important factors in obtaining better and more efficient operation.

Comments on Glossary

Comments or suggestions on the recently published *Glossary—Water and Sewage Control Engineering* will be very much appreciated. No revision is contemplated at present, but letters on this subject sent to the Association's office will be filed until such time as the Editorial Committee begins preparation of the next edition.



Percolation and Runoff

That the New Year finds us "contented" is, of course, obvious; that it finds us also content is perhaps less so, but if you'd ever seen us scrounge for suitable cover pictures you wouldn't be too surprised. At any rate, we want to take the occasion of a new "majority" cover to thank all of you who were good enough to give us counsel on the matter. You have yourselves to thank, too, for the more legible type on the backbone. As for the new hue, that should help you tell this year from last. As a matter of fact, looking at the present condition of our own backyard, we can express the hope that 1950 will be a green year in more ways than this.

New York's current water supply crisis may well be the price its people are paying for political detouring of long-range planning and businesslike management. Even granting that the war had a lot to do with postponing additional capacity and that the rainfall deficiency has been catastrophic in its effects, not only upon New York's supply, but upon those of neighboring communities whose utilities have had the best in administration, the facts of New York's water supply history now being uncovered are indicative of political leaks far more serious in their consequence than physical ones, and painful now to repair. All in all, it's a sad story and one that's becoming more difficult to smile about with each sunny day.

What was recently passed off as an inconvenient rainlessness has at this early December date become a major emergency, which may well, with each daily dwindle of an only 60-day supply, become much worse. Thus, more than just a filler for a dull day, water supply has suddenly become top priority news, worth at least one front-page headline a day in every metropolitan daily, one strident story in every radio newscast—worth even a lion's share of subway sentiment, usually reserved for such vital public issues as Joe DiMaggio's batting average. Only trouble is, the news is

(Continued on page 2)

(Continued from page 1)

bad and an at-last-water-conscious public is characteristically concerned most with its own conversation and its neighbor's conservation.

Whatever else results from the voluntary conservation now being enjoined and entreated by every means of public communication, whatever else results from the desperation tactics being employed by municipal authorities, the unprecedented publicity campaign has already been of inestimable value in making the public conscious of the fact that there is a water supply problem. Campaigns such as that of the New York *Times*, which, in boldface fillers on almost every page, gives advice on dishwashing, leak stopping, taking baths, cooling drinking water, shaving, laundering and a host of other household pursuits in which water can be conserved, have undoubtedly contributed much toward the savings already realized.* The series of front-page conservation suggestions in the New York *Sun* and similar public service messages in other newspapers cannot help but help. As for stories, articles, features and editorials, our office has become a veritable clip joint, which is fast taking on the appearance of lower Broadway after the Eisenhower welcome. In no uncertain terms, New Yorkers and their neighbors have water on the brain—a disorder we can hope will not be forgotten with the alleviation of the temporary emergency which caused it.

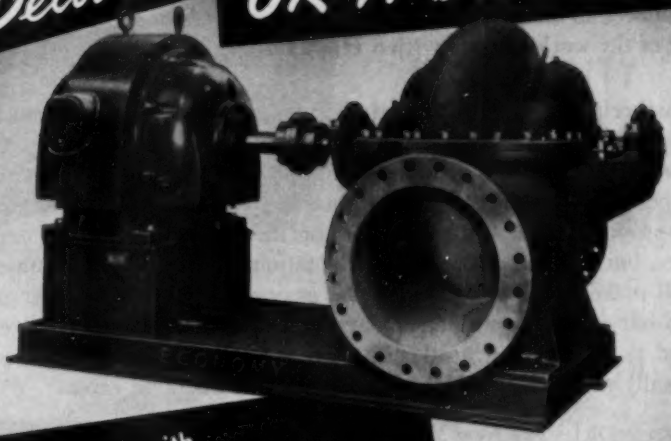
Even if the current water shortage lesson isn't permanently learned by the public, however, it should make a lasting impression on the minds of the water works men involved. And perhaps that impression will soon result in the kind of concerted attack on fundamental difficulties which has resolved other basic shortcomings in the field. Even now water works men are talking about the desirability of having the state take over responsibility for the development and allocation of its own water resources, with the idea of making possible an integrated program of exploitation and conservation. And, short of that, others see in the present emergency a lever by which they can pry loose the funds necessary to provide adequate reserves for future emergencies.

Currently, Britain, France, Switzerland and South Africa in addition to parts of Canada, New England and, of course, California have been suffering unprecedented drydom. Where next, or when, drought will strike is as difficult to predict as tomorrow's weather; but that it will strike and that it will wreak havoc when it does, unless water works men are adequately prepared for it, is as certain as yesterday's. And much as you, too,

* As of this proofreading a waterless Friday has just set New York consumption for the day back some 21 years. And if the unwashed and unshaven metropolites seemed more of 1933 than of 1929 vintage, at least they proved that voluntary conservation can be surprisingly effective if properly "sold." For more than purely aesthetic reasons, however, we'd prefer to see, and otherwise sense, New Yorkers showered, shaved and otherwise well watered, but unwasteful.

(Continued on page 4)

Deliver a drop... OR A DELUGE!



with

Economy

DOUBLE SUCTION PUMPS

. . Capacities from 10 to 15,000 G.P.M. at heads to 300 feet.

Economy Double Suction Pumps meet your needs . . . for most any volume. More than 1500 models designed for every type drive assure you the right pump for your requirements . . . with these advantages:

1. Complete rotor may be removed without exposing bearings which are enclosed in removable cartridges.
2. Shaft sleeves sealed to prevent leakage between sleeve and shaft.
3. Modern hydraulic design.
4. Flanged wearing rings "L" shaped, inward flow.
5. All parts made to limit gauges for interchangeability.
6. Unusually effective water seals.
7. No threads in center of shaft to start fatigue failure.
8. Large wells for lubrication with flushout for old lubricant.

For full details write Dept. AG-1 for Catalog 1147-A.
Centrifugal, axial and mixed flow pumps for all applications.

Economy Pumps Inc.

DIVISION OF HAMILTON THOMAS CORP. HAMILTON, OHIO

(*Continued from page 2*)

may have longed for the kind of public consciousness of water supply now rampant in New York, believe us, it ain't worth the price of the shortage.

Anyway, New England won't have to worry any more. Abe Weatherwise of the *Old Farmer's Almanac* has predicted the kind of "wet winter" we've all been looking for. Thus, for New England we can predict and for the rest of the world we can wish a **Happy New Year.**

Postscripting the conservation cause, at second hand we can report that television, too, has hopped aboard the water wagon—happily not with a demonstration of the type of wastefulness we've been exhorted to avoid. It has been radio, though, that has brought the message home, not only with appropriate messages every hour on the hour, timed to our expected activities, but with an excruciating adaptation of the "singing commercial" that will make us all happy when the emergency is over. Never one to turn up our nose at a million dollars worth of free publicity, we've even managed to swallow our aesthetic instincts long enough to render equally unmusically the most metrical of apparently innumerable verses:

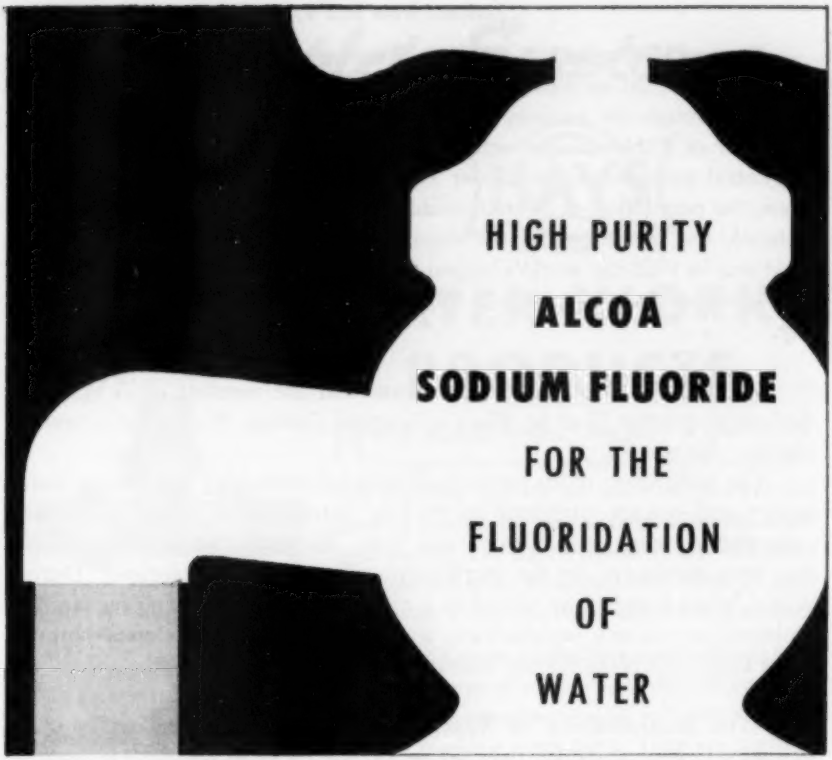
> Oh! The New York supply of H_2O
> Has reached a point where it's very, very low—
> So don't waste water when you take a bath or shave,
> Just turn off the tap and save! save! save!

How next our saving will be sold is difficult to imagine, but we'll not be too surprised if our harassed Mayor O'Dwyer sends each of us 8,000,000 wasters, one of those inescapable "singing telegrams," rent to the tune of the "Hyena Harangue." We'll no doubt deserve it.

Studies of water pollution by industrial wastes have received federal aid grants amounting to $891,487 through the U.S. Public Health Service under the 1948 Water Pollution Control Act. The grants have been made to 45 states (Arkansas, California and Virginia have not yet applied), 4 territories and the District of Columbia, and five interstate river basin agencies.

A conference on polluted irrigation waters is to be held in El Paso, Tex., on January 27. Under the joint sponsorship of the Public Health Service, El Paso and Texas health departments, the program will be devoted to discussions of such topics as the contamination of irrigation waters, the use of waste water and present standards for irrigation water. Inquiries should be addressed to Irving Gerring, Exec. Secy., Environmental Health Study Sec., Div. of Research Grants & Fellowships, National Institutes of Health, Bethesda 14, Md.

(*Continued on page 6*)



ALCOA Sodium Fluoride, like all other Alcoa Chemicals, has a uniform high degree of purity. It may be used with confidence for the fluoridation of water supplies. ALCOA Sodium Fluoride flows freely . . . is easy to handle . . . dissolves at a uniform rate. Besides that, ALCOA is a *dependable* source of supply.

If your community is fluoridating its water supply—or is considering doing so—let us discuss with you the properties of ALCOA Sodium Fluoride that make it particularly suitable for your use. Write to ALUMINUM COMPANY OF AMERICA, CHEMICALS DIVISION, 624 Gulf Bldg., Pittsburgh 19, Pennsylvania.

Alcoa Chemicals

ALCOA ®

ALUMINAS and FLUORIDES

ACTIVATED ALUMINAS • CALCINED ALUMINAS • HYDRATED ALUMINAS • TABULAR ALUMINAS • LOW SODA ALUMINAS ALUMINUM FLUORIDE • SODIUM FLUORIDE • SODIUM ACID FLUORIDE • FLUOBORIC ACID • CRYOLITE • GALLIUM

(Continued from page 4)

George H. Fenkell, A.W.W.A. Honorary Member and former President (1931), died on November 8, at the age of 76. He had earned wide acclaim through his services to the city of Detroit—as engineer, as Commissioner of Public Works, and for 20 years, until his retirement in 1938, as general manager of the Water Dept. In the course of those 20 years alone, the population of Detroit doubled, the water system was 99 per cent metered, the operations of the department were completely mechanized, what was in 1923 the world's largest filtration plant was designed and built, and a new source of supply was acquired to meet the needs of the growing city.

William I. Klein, noted consultant and life member of A.W.W.A., died on November 30 at St. Mary's Hospital, Orange, N.J., after a month's illness. He was 75.

The wide scope of his career had included consulting services on water supply and sewage problems to leading municipalities in 25 states and a number of countries in Europe and Asia. He participated in some of the first tests conducted on the sterilization of water with chlorine. During World Wars I and II he served as a civilian engineer working on sanitary problems at military installations, and he also helped develop a portable water treatment plant for use overseas during the first war.

"The Examination of Waters and Water Supplies," a standard British reference work for over 40 years, has received its sixth edition by Edwin Windle Taylor, deputy director of water examination for the London Metropolitan Water Board. The book is being distributed in the United States by the Blakiston Co., Philadelphia, and is priced at $12. In its 819 pages are included sections on analytical processes, the relation of geologic origin to the character of water, results and standards for sample analysis, waterborne diseases, and water treatment and purification.

(Continued on page 8)

If you want . . .
Cathodic PROTECTION
not just . . .
Cathodic Protection Equipment
call . . .
ELECTRO RUST-PROOFING

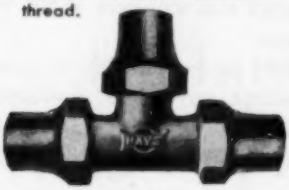
NO two corrosion problems are exactly alike — that's one reason stereotyped solutions won't work. Cathodic protection, properly engineered and applied, is economical, effective and practical. E.R.P. offers preliminary engineering, design, equipment and installation services for an individual solution to each particular problem. For data on cathodic protection of structures from pipe lines to elevated tanks, call on E.R.P. without obligation.

ELECTRO RUST-PROOFING CORP., (N. J.)
BELLEVILLE 9, NEW JERSEY
REPRESENTED IN PRINCIPAL CITIES

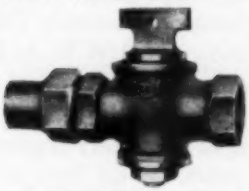
E-10

For Complete Service . . .

CATALOG No. 5200
Hays Corporation Stop with inlet A. W. W. A. standard thread.



CATALOG No. 5622
Hays Tee for copper to copper to copper connection.



CATALOG No. 5050
Hays Curb Stop for iron pipe to copper service connection.

CATALOG No. 5628
Hays Elbow for Male iron pipe to copper connection.

HAYS

WATER WORKS PRODUCTS

HAYS Manufacturing Company is one of the largest making a complete line of water service products, and for 80 years has enjoyed the prestige earned by unremitting insistence upon high quality. The HAYS line of fittings and other products is famous throughout the world for easy installation and a long life of trouble-free service.

All HAYS water works fittings are interchangeable with those of other manufacturers and corporation stops can be installed with any standard tapping machine equipment. They are made of highest quality 85-5-5-5 bronze, plugs are ground for perfect fit, specially lubricated for permanent easy turning, and hydrostatically tested at 200 pounds or more. Write for the new HAYS catalog showing the complete HAYS line of water works products.

CATALOG No. 5610
Hays Two Part Union for copper to copper connection.

CATALOG No. 5605
Hays Coupling for Male iron pipe to copper connection.

HAYS COPPER BRASS LEAD IRON
WATER WORKS PRODUCTS
HAYS MANUFACTURING CO., ERIE, PA.

(*Continued from page 6*)

A microfilm edition of the Journal has been arranged for by contract with University Microfilms, Ann Arbor, Mich., and will be made available to regular subscribers to the JOURNAL at an estimated price which will be approximately equal to the cost of binding. Libraries which subscribe to the new service will receive the microfilm record for the entire year—beginning with 1949—after the December issue has appeared. In the meantime, and for as long a period as demand warrants, the paper copies of the Journal are kept on the shelves unbound. At the expiration of the period of maximum use—which varies from library to library—the worn paper copies may be discarded and the microfilm edition substituted. The idea is that by eliminating the permanent binding of Journals, obtaining the microfilm edition will entail no new expense to libraries and will save about 94 per cent of their mounting space and storage costs.

Subscriptions for the microfilm edition should be sent directly to University Microfilms. That organization will accept no orders, however, except from regular subscribers to the paper edition of the journals it microfilms. Suggestions for viewing equipment and discounts on their purchase are also available from the firm.

Carl A. Hechmer, department engineer for the Washington Suburban Sanitary Commission, Hyattsville, Md., and A.W.W.A. Director from the Chesapeake Section, died on November 23 after a brief illness.

He had been engaged in sanitary engineering for 35 of his 54 years, having been associated with the Baltimore water department and the Maryland Health Dept. before joining the commission staff in 1918.

In 1919 he joined the Association and his many activities include membership in the Publication Committee, the Committee on Convention Publicity and the committee on the accounting *Manual*. He has also been Chairman of the Plant Management and Operation Div. and has served as Trustee, Chairman and Secretary-Treasurer of the old Four States Section, from which he received the Fuller Award in 1940.

The Proceedings of the International Water Supply Association's First General Assembly and Congress, held at Amsterdam, 1949, are being published. A limited number of copies, beyond those reserved before publication, may be obtained from the Secretary General of I.W.S.A. at 34 Park St., London, W.1, England, at a price to be announced.

(*Continued on page 10*)

Water Hardness Tests

in one minute

. . . Calcium or total hardness to 1 ppm $CaCO_3$

Precise, rapid determination of either *total hardness* or of *calcium* is now possible with revolutionary new methods. *Magnesium* is determined from the difference between total hardness and calcium.

Total hardness is measured by means of the Schwarzenbach method as adapted for convenient field use by Hall Laboratories, Inc. Instead of the tedious technique of the soap test or the uncertainties of other procedures, this method involves a simple direct titration with a sequestering reagent to a change in color of a special indicator. This color change is definite so that the end point is readily detected. Interferences are easily eliminated.

The test for calcium is similarly a direct titration to the color change of another indicator. No complicated heating, waiting, filtering, or estimating is required. The answer, correct to less than 1 ppm of calcium, can be found in a minute.

For information concerning these tests and the reagents used in them, write to Calgon, Inc. The coupon below is supplied for your convenience.

CALGON, INC.
HAGAN BUILDING
PITTSBURGH 30, PA.

Please send full information concerning the tests for total hardness and calcium in water.

Name .....

Position .....

Company .....

Street and Number .....

City ..... Zone .... State .....

HAGAN
HALL
BUROMIN
CALGON

calgon, inc.

A SUBSIDIARY OF HAGAN CORPORATION

HAGAN BUILDING
PITTSBURGH 30, PA.

(Continued from page 8)

A "Specification Index of Construction Items and Materials" has been compiled by Allen V. Rothermel for the use of architects, engineers and specification writers. The 69-page pamphlet includes a listing of standards of A.S.T.M., A.S.A., government specifications and specifications of other organizations. A.W.W.A. standards are included to the extent that they cover construction items, although some omissions and inconsistencies may be found. Copies may be obtained from the author, Camp Hill, Pa., at $2.50 each.

Hazards of chlorine dioxide use are documented and appropriate safety procedures recommended in Research Report No. 7 of the National Board of Fire Underwriters, 85 John St., New York 7, N.Y. Entitled "Precautionary Fire and Explosion Safeguards in the Use of Chlorine Dioxide for Industrial Bleaching," the 24-page booklet describes typical methods of generating ClO_2 from sodium chlorite and chlorine and discusses the necessary safety measures that should be taken to avoid explosion and contamination dangers. Copies are available on request from NBFU.

John S. Longwell has retired as chief engineer and general manager of the East Bay Municipal Utility Dist. after having served in that capacity for the past 15 years. He first joined the staff of the district as division engineer in 1924, about a year after it had been organized to serve Oakland, Berkeley, and the other Alameda and Contra Costa communities in California. Previously he had been with the U.S. Reclamation Service under Arthur P. Davis, who engineered the mountain water system for the district and became its first head. Under Longwell's administration, the system's facilities were expanded to meet the pressure of expanding population, the second Mokelumne Aqueduct was completed, and a $23,500,000 sewage disposal project was inaugurated.

(Continued on page 12)

BOND-O

A safe and dependable self-caulking, self-sealing compound for jointing water mains. Used with complete confidence by hundreds of water works.

BOND-O is machine-blended for absolute uniformity and contains a germicide to inhibit oxidation by sulfur bacteria. BOND-O Rubber Packing Gaskets are resilient—bacteria-free and quickest of all packings to install. Made in sizes 4" to 60".

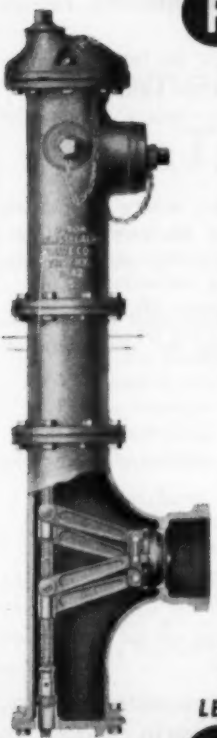
Northrop

NORTHROP & COMPANY, INC.
SPRING VALLEY, N. Y.

• Every Bond-o Joint is a Good Joint •

Just lift it out!

one reason for the LOW MAINTENANCE COST of the RENSSELAER Corey HYDRANT



One man, with no special tools or hoist, without digging, by opening valve and removing head, can easily remove and replace all working parts of the RenSSelaer Corey Hydrant. That is only ONE feature which our 65 years of experience have incorporated in this famous Hydrant. NO FLOODING in case of barrel breakage. Main valve MECHANICALLY LOCKED shut by steel forgings bearing against case *(illustrated left)*. No digging to renew broken barrel, thanks to flange at ground line. Hard rubber valve seats will not scar or leak. Drains fast, without clogging. No water hammer. Solid bronze protects long life of vital parts. There's no better investment than RenSSelaer Corey Hydrants . . . thousands in service prove it.

Working parts of Corey Hydrant

Experienced Field Representatives will bring you the benefits of RenSSelaer's years of experience with Hydrants AND Valves. Call nearest office.

LEADERSHIP FOR OVER 65 YEARS

RENSSELAER

Gate Valves • Square Bottom Valves • Topping Valves and Sleeves
Hydrants • Check Valves • Air Release Valves

RENSSELAER VALVE COMPANY • TROY, N. Y.

Division of Neptune Meter Company

Atlanta, Bala-Cynwyd, Pa., Chicago, Denver, Haverhill, Mass., Hornell, N. Y., Kansas City, Los Angeles, Memphis, Oklahoma City, Pittsburgh, San Francisco, Seattle, Waco

(*Continued from page 10*)

A specialized type of polio virus was the cause of a mild epidemic among members who attended the Oklahoma City meeting of the Southwest Section last October. Although the only apparent aftereffect of the attack has been a slight redness of face, the fact that it hit members "where it hurts most" is good reason to give warning to other sections. The specific virus involved in these cases was quickly detected and isolated, but it is known that immunity can be achieved only through development of resistance by understanding. Best epidemiological report is that provided by the Oklahoma City *Times* of October 21, quoted below:

WATER MEETING GIVEN WORKS BY "SPECIALIST"

The Southwest water works convention held here last week may have been a great success for its members, but it was even a greater one for a shy, foreign looking fellow—until he found himself in jail Friday.

Registering for the convention as Dr. Larry W. Costello, the little man gave a check for $50 to officials and announced he was here to give a talk on polio.

"I've been sent down specially from Mayo clinic in Rochester, Minn.," he explained.

Specialist Welcomed

Next, the "specialist" registered in the Biltmore Hotel, where he met his roommate, a Dallas resident also attending the convention. He met other convention members, too, all of whom seemed very impressed by his stature in the medical field.

When the convention closed a week ago Thursday, the little man disappeared. He would be remembered, however. Excited squawks to the police station showed he had:

Given the convention a $50 bogus check

Robbed his roommate of $70

"Borrowed" $50 and $75 from two other convention members because he had forgotten his billfold (he said).

Skipped out owing the hotel a large bill.

Suspect Arrested

Thursday afternoon police arrested a 47-year-old suspect. They said he gave three aliases under questioning, but finally presented his name as Harry Laverne Hanson. He told detective Jake Robertson he had served two prison sentences and was wanted for parole violation and forgery.

Sol Pincus has returned to New York to resume his consulting practice, after six months of service to the World Health Organization in Europe. In that period he acted as consultant on sanitary problems of various countries and helped set up the WHO Section of Environmental Sanitation.

Russell W. Lane has joined the staff of the Illinois State Water Survey Div. as chemist, specializing in boiler feedwater studies. In addition to other experience, he has spent nine years with National Aluminate Corp. in both research and field service on this subject.

(*Continued on page 14*)

Something About the Way They Are Installed

About 98 percent of a well water system is an underground construction project. Just how good the materials used are, or how poor the well was built, cannot be adequately checked by anyone in your organization. It is a question of depending on the reputation, integrity and skill of the builder.

First, Layne uses well building methods obtained from nearly three quarters of a century of world-wide experience. And second, everything used: casing, shutter screen, shafting, bearings, impellers, motors and controls are of the very finest quality. And furthermore, Layne well water systems are built to produce greater volumes of water than can be obtained from the conventional type of installation.

Layne's "know how" omits guess work and patch ups in construction errors by the less experienced. After the installation has been accepted, you have the long established and responsible Layne organization on which you can depend for repairs, parts or service when and if ever needed. For further information, catalogs, etc., address.

LAYNE & BOWLER, INC.

LAYNE

General Offices,
Memphis 8, Tenn.

WELL WATER SYSTEMS

(*Continued from page 12*)

With the death of John W. Van Atta, Executive Vice-Pres. & Gen. Mgr. of the Ralph B. Carter Co. of Hackensack, last December 7, P&R lost its favorite Jake and Broadway lost its premier golf champion, big game hunter, deep-sea fisherman and North Pole explorer. The fact that all of his adventures were experienced on Broadway after dark and that all of his triumphs took place in the sports columns of the *Daily News* never bothered Jake at all nor any of his host of Broadway big-name friends. From his days as a barkeep to his success as executive, Jake lived a legend, both loving and being loved by "The Great White Way."

Not as a director of the Water & Sewage Works Manufacturers Assn., but as a patron of New York's swank Versailles, who claimed to make his friends by bowling, did Jake first enter the columns of P&R. And his second entry, fittingly, was as an expert on the pursuit and capture of denizens of the deep. But if we needed any proof that others than us will miss Jake, the attendance and the flowers at his funeral were convincing evidence of his legion of friends.

As one of his columnist friends aptly epitaphed: "Goodbye, Jake; we had a lot of laughs together."

(*Continued on page 16*)

M-SCOPE Pipe Finder

LIGHTWEIGHT MODEL

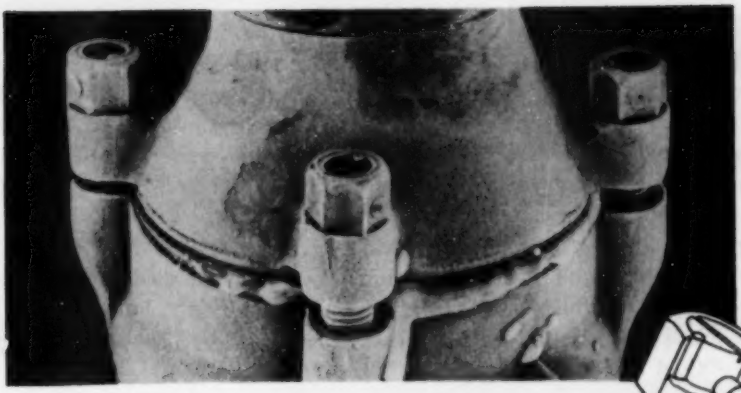
Catalog No. 25K

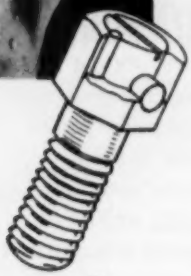
On Request

JOSEPH G. POLLARD CO., INC.

Pipe Line Equipment

New Hyde Park **New York**





SAFE service . . . all year 'round

Maximum protection against damage from freezing or excessive pressure is provided by the frost proof bolt, shown in this photograph of a CALMET Water Meter after freezing at 14 below zero. When the meter freezes or pressure exceeds 450 pounds, this feature and the split case construction allow the main case to separate without damage to any part. The CALMET will give accurate, long-lasting and economical service.

- ***SALES REPRESENTATIVES—Write for complete details of the CALMET franchise in your territory.***

CALMET WATER METER

MADE BY WELL MACHINERY & SUPPLY CO., INC.—FORT WORTH, TEXAS

(Continued from page 14)

The cold war suffered a serious setback recently with the mysterious disappearance of MR-1. But before you reach for your spyglasses, let us explain that MR-1 is a virus suspected of being the cause of the common cold. Isolated for the first time in 1947 at the National Institute of Health, where it has been incubated in a bath of fertile hen's eggs, MR-1 apparently flew the coop during a temporary mechanical failure in the laboratory refrigerator, fowling up some three years' of scientific study.

Actually it wasn't at all the amount of water which cold sufferers are supposed to drink which called our attention to the incident, but the intriguing headline which the New York *Times* placed on the Associated Press story—"Cold Virus Disapproves." Of course, that might have been a mere typographical slip, but knowing the *Times* as we do, we're quite sure something deeper was involved. Had we been in MR-1's spot we would have "disapproved" too of the idea of being incubated in a refrigerator with winter coming on.

Ah, well! Plenty of water and, when the A.M.A. isn't looking, perhaps an anti-histamine or two!

(Continued on page 18)

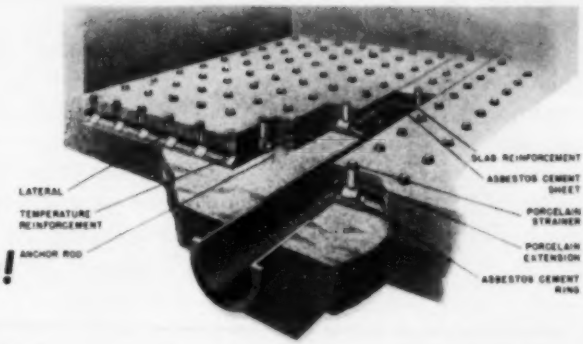
Tegul-
MINERALEAD
the best way
to join
bell and spigot pipe
Tegul-Mineralead is easy and clean to work with, economical, too—needs no skilled labor, caulking or deep bell holes. HYDE-RO RINGS, rubber ring packing, are recommended for use with Tegul-Mineralead. Please write us at 15 Walnut Street, Mertztown, Penna., and request Bulletin No. M10-1 and M10-5.
THE ATLAS MINERAL PRODUCTS COMPANY
Mertztown, Pa. Houston, Texas

"My Dad Was a Fireman"
"I'm the second generation of fire fighters, and I know what Dad knew fifty years ago, Kupferle Hydrants always work, and for me that's tops."
Send for specification sheets of the Kupferle line of Fire Hydrants.
JOHN C. KUPFERLE FOUNDRY CO.
ST. LOUIS
KUPFERLE FIRE HYDRANTS

Attention— All gravity filter Plant Engineers!

THE NEW PERMUTIT® MONOCRETE UNDERDRAIN

Easy to install... non-corrodible!



Check these Advantages:

- All parts of the underdrain are non-corrodible.
- All strainers are located in the same horizontal plane.
- Large laterals and header assure uniform collection and distribution of water.
- Strainers are uniformly spaced regardless of filter dimensions.
- Inexpensive and easily constructed.
- The monolithic construction is rigid and rugged.

The Permutit Monocrete Underdrain is of monolithic construction, the header and laterals consisting of conduits cast in concrete. Porcelain extension stems extend from the header and laterals to the top surface of the concrete; heavy porcelain strainers are screwed into these stems. The laterals are formed by specially designed inflatable rubber tubes which are removed after the concrete has set. The top slab of the header is then poured, using asbestos-cement sheet forms which are left in place.

For full information about this remarkable new unit, write to The Permutit Company, Dept. JA-1, 330 West 42nd St., New York 18, N. Y., or to the Permutit Company of Canada, Ltd., Montreal.

Permutit

WATER CONDITIONING HEADQUARTERS FOR OVER 35 YEARS

(Continued from page 16)

The reaction of fish to contamination in water has again been the subject of distinguished scientific discussion—this time at the Pittsburgh convention of the American Institute of Chemical Engineers. It was Dr. Charles E. Brown, Prof. of San. Eng. at Johns Hopkins Univ., who pointed out that one new method for testing the "fitness" of water for domestic use is by analyzing the different and distinguishable reactions of various types of fish to different kinds of contaminants. Insofar as the discussion which followed concerned the need for treating industrial wastes to prevent contamination of water supplies, all was well, but one point made during the session really bothered us: "These fish," it was pointed out, "can be 'trained' over a period of time to become accustomed to live in polluted waters."

Consider the possible consequences. It should certainly be simpler to train fish than to treat industrial wastes. And if fish can be trained, why not humans? And if humans, why bother to clean up the pollution of our beaches? And if the public has no reason to be concerned over such pollution, where are water works men going to get support for their own pollution control projects? No, it's time we called in the A.S.P.C.F. and put our own foot down, too. We for one will not be trained.

(Continued on page 20)

CYANAMID sulfate of alumina

assures
MAXIMUM
... plus
MINIMUM

- Removal of Suspended Impurities
- Freedom from Caking
- pH Range of Floc Formation — much wider than other coagulants
- Corrosion of Equipment — much less than other coagulants

... and NO clogging of dry feed machines

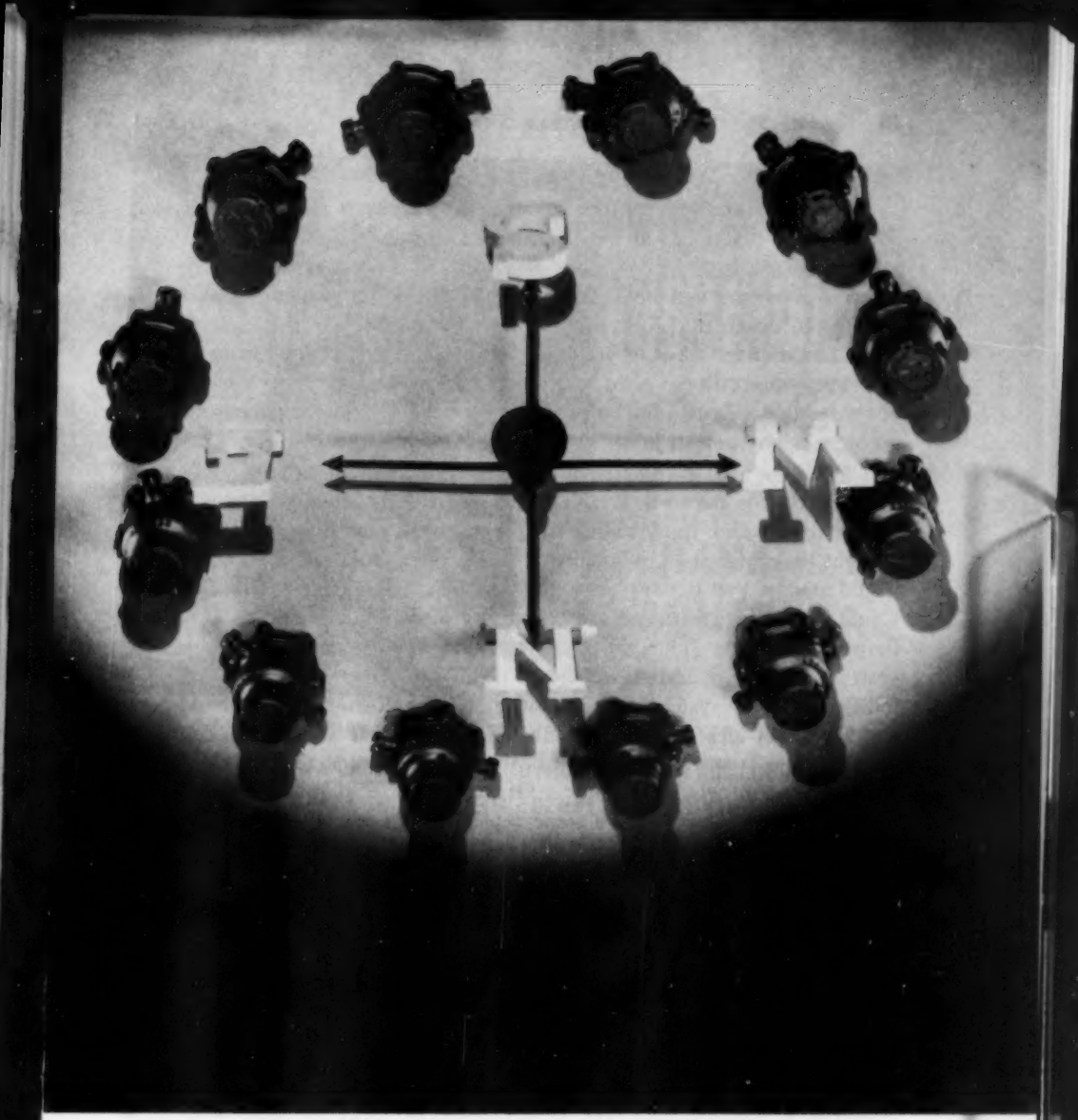
Write for full information

AMERICAN Cyanamid COMPANY

INDUSTRIAL CHEMICALS DIVISION

30 ROCKEFELLER PLAZA, NEW YORK 20, N. Y.

Sales Offices in Principal Cities



In the North or the South, in the far West or in the East, you will find Hersey Water Meters on the job. Experienced water works officials know that Hersey makes time-tested Water Meters to fit all climatic conditions and these Meters operate accurately, efficiently and at a low maintenance cost.

HERSEY MANUFACTURING COMPANY

SOUTH BOSTON, MASS.

BRANCH OFFICES: NEW YORK — PORTLAND, ORE. — PHILADELPHIA — ATLANTA — DALLAS — CHICAGO
SAN FRANCISCO — LOS ANGELES

(Continued from page 18)

The real answer to the problem of excess water consumption, which is now plaguing water works men throughout wide areas of shortage, was suggested in a recent issue of *American City* magazine. And the answer, of course, is simple: there is no such thing as water *consumption*. Water, *AC* points out, is *used* rather than consumed. In the same way as a used locomotive is sent to the shops for repair, says *AC*, used water is sent to the sewage treatment plant, returned to the ground or otherwise disposed of for repairs. *Ergo*, no water consumption; no excess water consumption problem. The only trouble is, people still *use* too much water.

Were we any less thirsty ourself right now, we might see fit to argue that at least in some sense the water people drink is actually *consumed*, but we are thirsty and, thus, willing to go along with anything that offers even a slight hope of help. Following through, then, from *AC*'s argument, we would assume that the answer to our problem of requiring too much water would be to reuse what we are now using more quickly, that is to reduce the repair period. Thus, in much the same way as some air conditioning systems are now operated, we should be able to achieve both domestic and industrial supply systems that are more or less self-contained—the old perpetual motion idea all over again. Of course, some industries—canning, bottling, even laundries—sell some of the water used with their products, but that replacement would be minor. Of course, too, evaporation, leakage and similar factors would involve some replacement even within the domestic system, but we should be able to depend upon rain for at least that much. All we need then is purification equipment adequate to the purpose of maintaining such a closed system—and we can't be too far away from that.

Actually, all this may have a familiar ring because it involves exactly the same procedure as that now being used, the only change being one of speed. It may sound, too, a little schoolbookish, as we seem to remember learning—was it in physics?—that nothing is actually consumed, but merely converted.

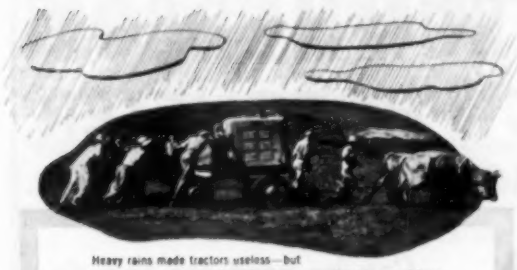
To return to *American City*'s point, though, we'll agree that *water consumption* is a pretty poor, yes, even misleading, term for *water use*. We might also point out that it was probably the choice of a psychologist who wanted to kid the public into thinking it was drinking an unused glass of water with each meal. And having thus agreed, we'll look forward to the day when we can physically join effluent to influent and really go around in circles.

Only incidentally, though also terminologically, we are suddenly struck with the fact that our old term "water rent" really was more accurate than our current "water rate."

Russell G. Davis has joined the executive sales force of Chain Belt Co., Milwaukee.

CENTRILINE
protects
the new
HAVANA
AQUEDUCT

▶▶ HAVANA'S BRAND NEW WELDED-STEEL AQUEDUCT HAS BEEN PERMANENTLY PROTECTED FROM TUBERCULATION AND LEAKAGE BY A THIN, DENSE CEMENT LINING PLACED BY THE CENTRILINE PROCESS.



Heavy rains made tractors useless—but Centrilining was completed in record time.

The new pipe line—68" in diameter and 28,809' long—was built for the City of Havana by M. A. González del Valle, General Contractor. The steel pipe was fabricated and installed by Compania de Ingenieria Morgran, S. A. of Havana. Because it is a vital link in Havana's new system it was lined in place with centrifugally applied cement mortar.

This protective cement mortar lining will more than pay for itself within a few years through sustained carrying capacity and low pumping costs.

▶▶▶ *Do you want the complete facts on Centrilining? Send for 28-page illustrated bulletin.*

CENTRILINE CORPORATION
140 CEDAR STREET • NEW YORK 6, N. Y.

CEMENT MORTAR LININGS FOR WATER MAINS
CENTRIFUGALLY APPLIED
in strict conformity
with A.W.W.A. Specifications

Correspondence

Illinois, Here We Come

To the Editor:

Dr. Buswell correctly accuses me of reading the "funnies" in the JOURNAL before looking at any of the papers published. This is due partly to your burial of the table of contents, and partly to the unirriguous wit of P&R.

I flushed with glee on reading your comments about solving southern California's water difficulties. It is probably time we realized that there is a wet ceiling to the growth of population in certain areas.

This may be the first recorded method of dampening a Californian's enthusiasm. One solution for the Californians would be to move to Illinois where water resources are abundant.

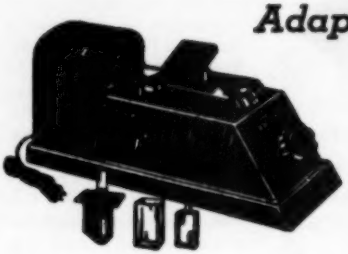
H. E. HUDSON JR.

P.S. We also have more climate.

Head, Engineering Sub-Division
State Water Survey Division
Urbana, Ill.; Dec. 5, 1949

Don't look now, but our neck is sticking out—like a camel's. And if friend Hudson will include us Easterners in his invitation, too, perhaps the "twain shall meet" after all—in Illinois, that is, where the climate apparently doesn't set a "wet ceiling," but is one. As for the "funnies," we're sorry now we exhumed the contents, and hope we haven't there, too, completely undone ourself.—Ed.

KLETT SUMMERSON
ELECTRIC PHOTOMETER



Adaptable for Use in Water Analysis

Can be used for any determination in which color or turbidity can be developed in proportion to substance to be determined

KLETT MANUFACTURING CO.
179 EAST 87th STREET · NEW YORK, N. Y.

removed under pressure

This pipe section was cut, under pressure, from a 48″ main without shut-down or other interruption to service. The operation was performed in the course of inserting a gate valve in a 48″ cast iron main, in the distribution system of the Water Bureau, City of Philadelphia, Pa.

Gate valves can be inserted under *pressure* by SMITH in cast iron, asbestos–cement or steel water mains, sizes 4″ and larger, without shutting off service or dewatering the line.

38

THE A. P. SMITH MFG. CO.

ESTABLISHED 1877

EAST ORANGE NEW JERSEY

Professional Services

ALBRIGHT & FRIEL, INC.

Consulting Engineers

Water, Sewage and Industrial Waste Problems
Airfields, Refuse Incinerators, Power Plants
Industrial Buildings
City Planning Reports Valuations
Laboratory

121 S. Broad St. **Philadelphia 7, Pa.**

CLINTON L. BOGERT ASSOCIATES

Consulting Engineers

CLINTON L. BOGERT — IVAN L. BOGERT
J. M. M. GREIG — ROBERT A. LINCOLN
DONALD M. DITMARS — ARTHUR P. ACKERMAN

Water and Sewage Works
Refuse Disposal — Industrial Wastes
Drainage — Flood Control

624 Madison Avenue **New York 22, N. Y.**

CHAS. B. BURDICK — LOUIS R. HOWSON
DONALD H. MAXWELL

ALVORD, BURDICK & HOWSON

Engineers

Water Works, Water Purification, Flood Relief, Sewerage, Sewage Disposal
Drainage, Appraisals, Power Generation

Civic Opera Building **Chicago 6**

BOWE, ALBERTSON & ASSOCIATES

Engineers

Sewerage—Sewage Treatment
Water Supply—Purification
Refuse Disposal—Analyses
Valuations—Reports—Designs

110 Williams St. **New York 7, N.Y.**
2082 Kings Highway **Fairfield, Conn.**

CARL A. BAYS & ASSOCIATES

Geologists—Engineers—Geophysicists
Industrial Consultants

Office and Laboratory—308 N. Orchard St.
Mail Address—P.O. Box 189

Urbana, Illinois

BUCK, SEIFERT AND JOST

Consulting Engineers
(Formerly Nicholas S. Hill Associates)

WATER SUPPLY—SEWAGE DISPOSAL—
HYDRAULIC DEVELOPMENTS

Reports, Investigations, Valuations, Rates, Design, Construction, Operation, Management, Chemical and Biological Laboratories

112 E. 19th St., New York 3, N. Y.

A. S. BEHRMAN

Chemical Consultant

Water Treatment
Ion Exchange Processes and Materials
Patents

9 S. Clinton St. **Chicago 6, Ill.**

BURGESS & NIPLE

Consulting Engineers
(Established 1908)

Water supply, treatment and distribution
Sewage and industrial wastes disposal
Investigations, reports, appraisals, rates
Airports Municipal Engineering Supervision

584 E. Broad St. **Columbus 15, Ohio**

BLACK & VEATCH

Consulting Engineers

4706 Broadway, Kansas City 2, Mo.

Water Supply Purification and Distribution; Electric Lighting and Power Generation, Transmission and Distribution; Sewerage and Sewage Disposal; Valuations, Special Investigations and Reports

BURNS & McDONNELL ENGINEERING CO.

Consulting Engineers—51 Years

Water Works, Light and Power, Sewerage, Reports, Designs, Appraisals, Rate Investigations.

Box 7088 Country Club P.O., Kansas City 2, Mo.
Office: 95th & Troost Ave.

BLACK LABORATORIES, INC.

Consulting Engineers and Chemists

on all problems of

Water, Sewage and Waste Treatment

ANALYSIS—TREATMENT—
CONTROL—RESEARCH

968 S. Oak St. **Gainesville, Fla.**

JAMES M. CAIRD

Established 1898

C. E. CLIFTON, H. A. BENNETT

Chemist and Bacteriologist

WATER ANALYSIS
TESTS OF FILTER PLANTS

Cannon Bldg. **Troy, N. Y.**

CAMP, DRESSER & McKEE

Consulting Engineers

Water Works, Water Treatment,
Sewerage and Wastes Disposal,
Flood Control

Investigations, Reports, Design
Supervision, Research, Development

6 Beacon St. **Boston 8, Mass.**

GANNETT FLEMING CORDDRY & CARPENTER, Inc.

Engineers

Water Works—Sewerage
Industrial Wastes—Garbage Disposal
Roads—Airports—Bridges—Flood Control
Town Planning—Appraisals
Investigations & Reports

Harrisburg, Pa.
Scranton, Pa. **Pittsburgh, Pa.**

THE CHESTER ENGINEERS

Water Supply and Purification,
Sewerage Systems, Sewage and
Industrial Waste Treatment,
Power Development and Applications,
Investigations and Reports,
Valuations and Rates

210 E. Park Way at Sandusky
PITTSBURGH 12, PA.

GILBERT ASSOCIATES, INC.

Engineers and Consultants

Water Supply and Purification
Sewage and Industrial Waste Treatment
Chemical Laboratory Service
Investigations and Reports

New York **Reading, Pa.** **Washington**
Houston **Philadelphia**

CONSOER, TOWNSEND & ASSOCIATES

Water Supply—Sewerage
Flood Control & Drainage—Bridges
Ornamental Street Lighting—Paving
Light & Power Plants—Appraisals

351 E. Ohio St. **Chicago 11**

IVAN M. GLACE

Consulting Sanitary Engineer

Water Supply and Purification
Sewerage, Sewage and Industrial
Wastes Treatment
Design, Construction & Supervision of
Operation
Laboratory Service

1001 N. Front St. **Harrisburg, Pa.**

DE LEUW, CATHER & COMPANY

Water Supply — Sewerage
Railroads — Highways

Grade Separations—Bridges—Subways
Local Transportation

Investigations—Reports—Appraisals
Plans and Supervision of Construction

150 N. Wacker Drive **79 McAllister St.**
Chicago 6 **San Francisco 2**

GREELEY & HANSEN

Engineers

Water Supply, Water Purification
Sewerage, Sewage Treatment
Flood Control, Drainage, Refuse Disposal

220 S. State Street, Chicago 4

FAY, SPOFFORD & THORNDIKE

Engineers

Charles E. Spofford — Ralph W. Horne
John Ayer — William L. Hyland
Bion A. Bowman — Frank L. Lincoln
Carroll A. Farwell — Howard J. Williams

Water Supply and Distribution—Drainage
Sewerage and Sewage Treatment—Airports

Investigations Reports Designs Valuations
Supervision of Construction

Boston **New York**

HAVENS & EMERSON

W. L. Havens C. A. Emerson
A. A. Burger F. C. Tolles F. W. Jones

Consulting Engineers

Water, Sewage, Garbage, Industrial
Wastes, Valuations—Laboratories

Leader Bldg. **Woolworth Bldg.**
CLEVELAND 14 **NEW YORK 7**

O. S. FENT

Consulting Ground Water Geologist

Water Supply Surveys
Complete Test Drilling Service

Box 477 **Salina, Kansas**

CHARLES HAYDOCK

Consulting Engineer

Water Works and Sanitation Industrial Wastes
Design, Construction, Operation and Management
Reports and Valuations

2314 Girard Trust Co. Bldg.
Broad St. & S. Penn Square
Philadelphia 2

Professional Services

HITCHCOCK & ESTABROOK, INC.

Lester D. Lee, Associate

Consultants to Municipalities since 1920

Water, Sewerage, Paving, Power Plants,
Airports, Reports and Appraisals

521 Sexton Bldg., Minneapolis 15, Minn.

Roberto Meneses Hoyos & Co.

Ground Water Engineers

Water Supply — Geophysics
Test Drilling — Flow Tests
Explorations — Reports
Design, Valuations & Supervision

Reforma 12 — **Mexico City**

HORNER & SHIFRIN

Consulting Engineers

W. W. Horner — S. W. Jens
H. Shifrin — E. E. Bloss
V. C. Lischer

Water Supply—Airports—Hydraulic Engineering—Sewerage—Sewage Treatment—Municipal Engineering—Reports

Shell Building — **St. Louis 3, Mo.**

METCALF & EDDY

Engineers

Water, Sewage, Drainage, Refuse
and Industrial Wastes Problems
Airfields — Valuations
Laboratory

Statler Building, Boston 16 — **111 Sutter St., San Francisco 4**

ROBERT W. HUNT CO.

Inspection Engineers

(Established 1888)

Inspection and Test at Point
of Origin of Pumps, Tanks,
Conduit, Pipe and Accessories

**175 W. Jackson Blvd.
Chicago 4, Ill.
and Principal Mfg. Centers**

THE H. C. NUTTING COMPANY

Engineers

Water Distribution Studies
Water Waste Surveys
Trunk Main Surveys
Meter and Fire Flow Test

4120 Airport Road — **Cincinnati 26, Ohio**

JONES, HENRY & SCHOONMAKER

(Formerly Jones & Henry)

Consulting Sanitary Engineers

Water Works
Sewerage & Treatment
Waste Disposal

Security Bldg. — **Toledo 4, Ohio**

Parsons, Brinckerhoff, Hall & Macdonald

G. Gale Dixon, Associate

Engineers

Dams — Water Works — Sewerage
Airports — Bridges — Tunnels
Traffic & Transportation Reports — Highways
Subways — Foundations
Harbor Works — Valuations
Power Developments — Industrial Buildings

51 Broadway, New York 6, N.Y.

MORRIS KNOWLES, INC.

Engineers

Water Supply and Purification,
Sewerage and Sewage Disposal,
Industrial Wastes, Valuations,
Laboratory, City Planning.

Park Building — **Pittsburgh 22, Pa.**

MALCOLM PIRNIE ENGINEERS

Civil & Sanitary Engineers

MALCOLM PIRNIE — ERNEST W. WHITLOCK
RICHARD HAZEN — G. G. WERNER, JR.

Investigations, Reports, Plans
Supervision of Construction and Operations
Appraisals and Rates

25 W. 43rd St. — **New York 18, N. Y.**

R. M. LEGGETTE

Consulting Ground Water Geologist

Water Supply — Salt Water Problems
Dewatering — Investigations
Recharging — Reports

551 Fifth Avenue — **New York 17, N. Y.**

THE PITOMETER COMPANY

Engineers

Water Waste Surveys
Trunk Main Surveys
Water Distribution Studies
Penstock Gaugings

50 Church St. — **New York 7, N. Y.**

LEE T. PURCELL

Consulting Engineer

Water Supply & Purification: Sewerage & Sewage Disposal; Industrial Wastes; Swimming Pool Control; Investigations & Reports; Design; Supervision of Construction; Operation

Analytical Laboratories

1 Lee Place **Paterson 1, N. J.**

STANLEY ENGINEERING COMPANY

Waterworks—Sewerage
Drainage—Flood Control
Airports—Electric Power

Hershey Building
Muscatine, Ia.

THOMAS M. RIDDICK

Consulting Engineer and Chemist

Municipal and Industrial Water Purification, Sewage Treatment, Plant Supervision, Industrial Waste Treatment, Laboratories for Chemical and Bacteriological Analyses

369 E. 149th St. **New York 55, N.Y.**

ALDEN E. STILSON & ASSOCIATES

Limited

Consulting Engineers

Water Supply Sewerage Waste Disposal
Mechanical Structural

Surveys Reports Appraisals

209 South High St. **Columbus, Ohio**

RIPPLE & HOWE

Consulting Engineers

O. J. RIPPLE B. V. HOWE

Appraisals—Reports
Design—Supervision

Water Works Systems, Filtration and Softening Plants, Reservoirs, and Dams, Sanitary and Storm Sewers, Sewage Treatment Plants, Refuse Disposal, Airports

426 Cooper Bldg., Denver 2, Colo.

WARD & STRAND

Engineers

Water — Power
Sewerage — Drainage
Industrial Wastes — Industrial Building
Paving

1 W. Main St. **Madison 3, Wis.**

NICHOLAS A. ROSE

Consulting Ground Water Geologist

Investigations
Reports
Advisory Service

1309 Anita Ave. **Houston 4, Tex.**

WESTON & SAMPSON

Consulting Engineers

Water Supply and Purification; Sewerage, Sewage and Industrial Waste Treatment. Reports, Designs, Supervision of Construction and Operation; Valuations. Chemical and Bacteriological Analyses

14 Beacon Street **Boston 8, Mass.**

RUSSELL & AXON

Consulting Engineers

GEO. S. RUSSELL F. E. WENGER
JOE WILLIAMSON, JR.

Water Works, Sewerage, Sewage Disposal, Industrial and Power Plants, Appraisals

408 Olive St. **Municipal Airport**
St. Louis 2, Mo. **Daytona Beach, Fla.**

WHITMAN & HOWARD

Engineers

(Est. 1869.)

Investigations, Designs, Estimates, Reports and Supervision, Valuations, etc., in all Water Works and Sewerage Problems

89 Broad St. **Boston, Mass.**

J. E. SIRRINE COMPANY

Engineers

Water Supply & Purification,
Sewage & Industrial Waste Disposal,
Stream Pollution Reports,
Utilities, Analyses

Greenville **South Carolina**

WHITMAN, REQUARDT & ASSOCIATES

Engineers *Consultants*

Civil—Sanitary—Structural
Mechanical—Electrical
Reports, Plans,
Supervision, Appraisals

1304 St. Paul St. **Baltimore 2, Md.**

Membership Changes

NEW MEMBERS

Applications received November 1 to 30, 1949

Allen, Walter B., Mgr., Art Concrete Works, 2400 Adeline, Oakland 7, Calif. (Oct. '49) *M*

Bailey, Oliver W., Structural Engr., Planning & Reports Section, Eng. Branch, Water Supply Div., Corps of Engrs., 1st & Douglas Sts., N.W., Washington, D.C. (Oct. '49) *MPR*

Barnes, Herschel E., Owner, Barnes Tank & Bridge Co., Box 33, East Prairie, Mo. (Oct. '49) *M*

Bassett, Kenneth M., Arizona Edison Co., Inc., Box 113, Yuma, Ariz. (Oct. '49) *M*

Beltz, Chester L., Owner & Operator, C. L. Beltz Water System, 700—30th Ave., Santa Cruz, Calif. (Oct. '49) *M*

Bigglestone, H. C., II, Resident Engr., Board of Fire Underwriters of the Pacific, 921 Title & Trust Bldg., Phoenix, Ariz. (Oct. '49) *P*

Biloxi Water Works Dept., Gordon A. Dacey, Comr. of Public Works, Biloxi, Miss. (Corp. M. Oct. '49)

Boardman, William H., Civ., Hydr. & San. Engr., 426 Walnut St., Philadelphia 6, Pa. (Oct. '49) *MPR*

Bonser, Charles H., Mgr., Sativa Los Angeles County Water Dist., 2015 Hatchway, Compton, Calif. (Oct. '49) *M*

Boyd, H. M., *see* Lytle Creek Water & Improvement Co.

Bronzonie, John A., Inspector of Plumbing, Dist. of Columbia Govt., Dept. of Inspection, 14th & Pennsylvania Ave., N.W., Washington, D.C. (Oct. '49)

Burke, Richard H., Secy. & Counsel, Board of Water Supply, 120 Wall St., New York 5, N.Y. (Oct. '49) *R*

Canton, Town of, Gordon Miller, Foreman Water Dept., Box 987, City Hall, Canton, N.C. (Corp. M. Oct. '49)

Carlson, Algot E., Filtration Plant Supt., 1151 Bush St., Martinez, Calif. (Oct. '49) *P*

Carlson, Donald O., Research Engr., Leaching Plant, Inspiration Cons. Copper Co., Inspiration, Ariz. (Oct. '49) *P*

Church, William Howard, City Mgr., 205 N. Greenleaf Ave., Whittier, Calif. (Oct. '49) *MR*

Citizens Utilities Co. of California, F. J. Keys, Vice-Pres., 1607 Del Paso Blvd., Sacramento, Calif. (Corp. M. Oct. '49)

Cockrill, Mark D., Pres., Mark Cockrill Contracting Co., Inc., 1917 W. Grant, Phoenix, Ariz. (Oct. '49) *P*

Coleman, H. O., Auditor, Water Works, City Hall, Atlanta, Ga. (Oct. '49)

Corrick, John A., Treas., Clinton Campbell Contractor, Inc., 1814 S. 7th Ave., Phoenix, Ariz. (Oct. '49) *P*

Cox, Henry H., Supt., Water Works, Mt. Vernon, Ky. (Oct. '49) *MP*

Crandell, James H., Pump Operator, Corps of Engrs., 5900 MacArthur Blvd., Washington, D.C. (Oct. '49)

Crescent City Water Co., Otto E. Never, Pres., Box 771, Eureka, Calif. (Corp. M. Oct. '49) *MP*

Crystal Mutual Water Co., C. Dival Eib, Pres., 14260 E. Keese Drive, Whittier, Calif. (Corp. M. Oct. '49)

Curry, Willford G., Water & Sewage Plant Supervisor, Folsom State Prison, Represa, Calif. (Oct. '49) *P*

Dacey, Gordon A., *see* Biloxi Water Works Dept.

DeConcini, Evo, National City Water Co., 415 Valley Bank Bldg., Tucson, Ariz. (Oct. '49) *M*

Downey, James J., Owner, Penngrove Water Co., Penngrove, Calif. (Oct. '49) *MPR*

(*Continued on page 30*)

40 Years of Protection

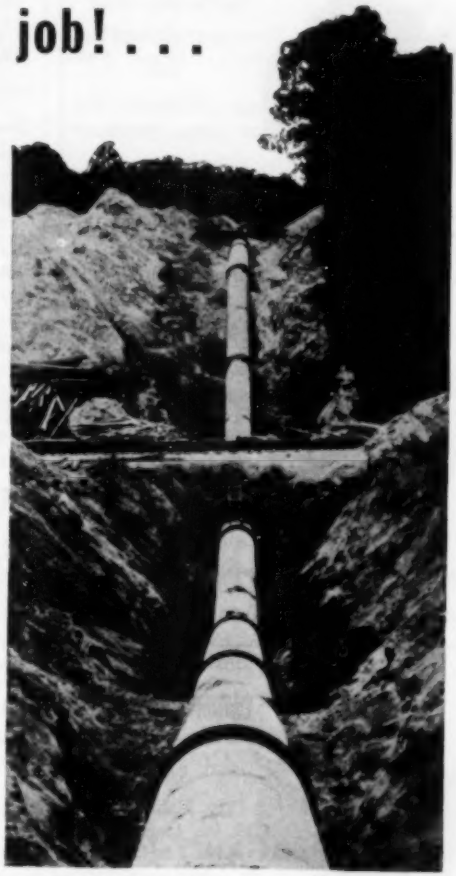
earned Koppers Bitumastic this job! . . .

In 1948—when the city of Springfield, Mass., met increasing demands for water with 26,000 feet of new 48-inch line — Koppers Bitumastic® 70-B Enamel was specified as an interior and exterior protective coating. With good reason, too, for Springfield engineers had first-hand knowledge of the long-lasting protection of Koppers Bitumastic.

In 1909, when Springfield's Westfield Little River System was started, seven miles of 42-inch line were coated with Koppers Bitumastic. For 40 years, the Bitumastic Coating has kept flow capacity high and guarded the line against corrosion. Other lines, laid in 1929 and 1943, also are protected by Bitumastic.

Inside the pipe, the glass-smooth, high-gloss surface of Koppers Bitumastic Enamel forms a barrier against tuberculation, rust and corrosion. Bitumastic keeps water from touching the underlying steel pipe surfaces . . . protects against the corrosive action of soil chemicals . . . has high electrical resistance. And it won't deteriorate with age.

If you're planning a water or sewage line, turn the coating job over to engineers of Koppers Contract Department. They'll handle it from start to finish, assuring long-lasting protection for the project. Write for complete information on Koppers Contract Service.



Springfield's new 48-inch line is shown crossing beneath railroad tracks through 72-inch pipe placed in an open cut. The new steel line, like others in the Springfield system, is protected with Koppers Bitumastic Enamel.

KOPPERS BITUMASTIC ENAMELS

KOPPERS COMPANY, INC., Dept. 114T Pittsburgh 19, Pa.

(*Continued from page 28*)

Doyle, M. E., Chief Engr., Fulton County Health Dept., 160 Pryor St., S.E., Atlanta, Ga. (Oct. '49)

Dundas, Ray W., Sales Engr., Edward R. Bacon Co., 17th & Folsom, San Francisco, Calif. (Oct. '49)

Eib, C. Dival, *see* Crystal Mutual Water Co.

Estes, John M., Foreman, Water Dept., 375 S. Euclid Ave., Upland, Calif. (Oct. '49) *M*

Fenrich, E. G., Mgr., Chlorite Div., Mathieson Chemical Corp., Baltimore, Md. (Oct. '49)

Fitzpatrick, Joseph Ware, San. Engr., Federal Security Agency, Public Health Service Region No. 3, Washington, D.C. (Oct. '49) *M*

Florida Utilities Corp., Edmund E. Siewert, Water Plant Operator, 520 Park Ave., S., Winter Park, Fla. (Corp. M. Oct. '49) *P*

Forsyth, Frank B., Pres., Wilmot Water Co., Inc., 422 E. Mabel, Tucson, Ariz. (Oct. '49)

Fremming, Gordon H., Pres., Acme Water Co., Inc., 3668 S. Lundy Ave., Tucson, Ariz. (Oct. '49)

Gardiner, J. W., Owner, Water Works, Box 607, Isleton, Calif. (Oct. '49) *M*

Giannini, Amerigo G., Supt. of Operations, Dept. of Water Works, City Hall, Hammond, Ind. (Oct. '49)

Gilliam, C. O., Cons. Engr., Yuma Blue Print, Box 669, Yuma, Ariz. (Oct. '49) *P*

Gomez Laurens, Gilberto, Univ. of Michigan, 1442 Washington Heights, Ann Arbor, Mich. (Jr. M. Oct. '49) *MPR*

Graham, Ralph E., City Engr., City of West Covina, 2133 W. Garvey Ave., Covina, Calif. (Oct. '49) *M*

Gravell, Hubert F., Plant Foreman, Water Dept., 215 W. Broadway, Long Beach, Calif. (Oct. '49) *M*

Gray, Walter, Water Works Operator, Water Dept., Clarksville, Tenn. (Oct. '49)

Hammes, Kenneth W., City Engr., Globe, Ariz. (Oct. '49) *MR*

Henrique Barbosa, Manuel, Civ. Engr., 719 Church St., Ann Arbor, Mich. (Jr. M. Oct. '49) *P*

Holman, Albert L., Chem. Engr., Covington City Water Works, Ft. Thomas, Ky. (Oct. '49)

Hoos, Richard E., Sales Engr., Wallace & Tiernan Co., Inc., 1111—17th St., N.W., Washington 6, D.C. (Oct. '49) *P*

Hoy, Nevin D., Dist. Geologist, U.S. Geological Survey, Miami, Fla. (Oct. '49) *R*

Hugh, Leslie M., Field Repr., Water Tower Paint & Repair Co., Clear Lake, Iowa (Oct. '49)

Humphries, William L., Mgr., Miami Div., Arizona Edison Co., Miami, Ariz. (Oct. '49) *M*

Jamison, Jacob Harry, Partner, Utilities Service Co., 406 S. Bascom Ave., San Jose, Calif. (Oct. '49) *M*

Janesville Water Dept., Joseph Lustig, City Engr., City Hall, Janesville, Wis. (Corp. M. Oct. '49)

Johnson, Elmer Otho, Jr., Dist. Engr., Byron Jackson Co., 3700 Grand Ave., Phoenix, Ariz. (Oct. '49) *MR*

Johnson, John W., Jr., San. Engr., L. A. Schmidt Jr., Engrs., Dix Dam, Harrodsburg, Ky. (Oct. '49) *P*

Keith, Edward C., City Civ. Engr., City Hall, Evansville, Ind. (Oct. '49)

Kettering, Charles B., Supt., Leaching Plant, Inspiration Cons. Copper Co., Inspiration, Ariz. (Oct. '49) *P*

Keys, F. J., *see* Citizens Utilities Co. of California

Kidd, Noel, Foreman, Munic. Utilities, U.S. Bureau of Mines, 721 Whiteriver Ave., Rifle, Colo. (Oct. '49)

Kiel, Paul M., Div. Engr., Div. of Water, 565 Erie St., Toledo 2, Ohio (Oct. '49) *M*

Kinney, John E., San. Engr., Ohio River Valley Water Sanitation Com., 414 Walnut St., Cincinnati 2, Ohio (Oct. '49) *R*

Kisling, A. C., Sales Repr., Neptune Meter Co., 320 Market St., San Francisco, Calif. (Oct. '49)

Lamb, James C., III, Instructor, Civ. Eng. Dept., Virginia Military Inst., Lexington, Va. (Oct. '49)

Latimer, Thomas M., Assoc. Engr., Water Div., Dist. of Columbia Govt., 504 Wayne Ave., Silver Spring, Md. (Oct. '49)

(*Continued on page 32*)

1879—ROSS—1879

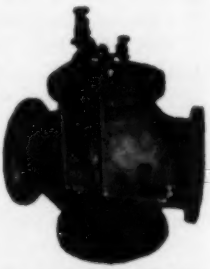
Automatic Valves

ALTITUDE VALVE

Controls elevation of water in tanks, basins and reservoirs

1. Single Acting
2. Double Acting

Maintains safe operating pressures for conduits, distribution and pump discharge



SURGE-RELIEF VALVE

REDUCING VALVE

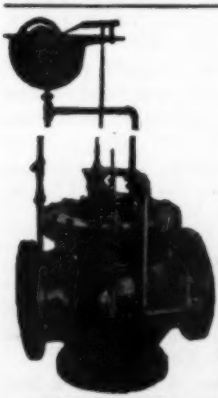
Maintains desired discharge pressure regardless of change in rate of flow

Regulates pressure in gravity and pump systems; between reservoirs and zones of different pressures, etc.

A self contained unit with three or more automatic controls

COMBINATION VALVE

Combination automatic control both directions through the valve.

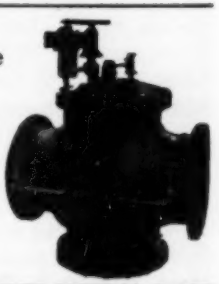


FLOAT VALVE

Maintains levels in tank, reservoir or basin

1. As direct acting
2. Pilot operated and with float traveling between two stops, for upper and lower limit of water elevation.

Electric remote control—solenoid or motor can be furnished



REMOTE CONTROL VALVE

Adapted for use as primary or secondary control on any of the hydraulically controlled or operated valves.

Packing Replacements for all Ross Valves Through Top of Valve

ROSS VALVE MFG. CO., INC., P. O. BOX 593, TROY, N. Y.

(Continued from page 30)

Layson, J. Don, Engr.-Director, Environmental Sanitation, San Joaquin Local Health Dist., Stockton, Calif. (Oct. '49) *MPR*

Levin, Philip, Service & Control Operator, Bureau of Water Supply, 510 Municipal Bldg., Baltimore, Md. (Oct. '49) *M*

Long, Russell F., Eng. Estimator, Mark Cockrill Contracting Co., Inc., 1917 W. Grant, Phoenix, Ariz. (Oct. '49) *P*

Longwell, Clyde J., Water Well Drilling Contractor, Pesco Botteravia Lateral Rd., Santa Maria, Calif. (Oct. '49) *R*

Lopez, Elisa N. (Miss), Secy., Bureau of Sanitation, State Dept. of Health, 917 S. Montezuma Ave., Phoenix, Ariz. (Oct. '49) *P*

Love, Milton A., Eng. Estimator, Mark Cockrill Contracting Co., Inc., 1917 W. Grant, Phoenix, Ariz. (Oct. '49) *P*

Lustig, Joseph, *see* Janesville Water Dept.

Lytle Creek Water & Improvement Co., H. M. Boyd, Secy.-Treas., 102 N. Riverside Ave., Rialto, Calif. (Corp. M. Oct. '49) *MR*

Malony, George Allison, San. Engr., Brown & Caldwell, 233 Sansome St., San Francisco, Calif. (Oct. '49) *P*

March, Joseph Wade, Prof., Nova Scotia Tech. College, Halifax, N.S. (Oct. '49)

McIver, R. W., Chemist, Louisville-Jefferson County Board of Health, 113 Arbor Park, S., Louisville, Ky. (Oct. '49)

McLane, Fred L., Director, Water Works, Newport, Ky. (Oct. '49)

Miller, Gordon, *see* Canton, Town of

Mills, Robert Charles, Sales Engr., Lee Redman Equipment Co., 610 S. 19th Ave., Phoenix, Ariz. (Oct. '49) *P*

Mortenson, James A., Jr., Partner, Northern Water Utility Co., 334 W. Jefferson, Phoenix, Ariz. (Oct. '49) *MPR*

Moye, Malcolm A., Jr., Gen. Supt., c/o Ivy H. Smith Co., Box 5098, Jacksonville, Fla. (Oct. '49) *P*

Narup, C. E., City Engr., Fayetteville, Tenn. (Oct. '49)

Navas, Stanley R., Sales Mgr., Concrete Pipe & Products Co., Inc., Box 1223, Richmond, Va. (Oct. '49)

Neal, A. H., Mech. Engr., Inspiration Cons. Copper Co., Inspiration, Ariz. (Oct. '49) *MP*

Nesbitt, Thomas J., Asst. City Engr., City Hall, Mesa, Ariz. (Oct. '49) *R*

Never, Otto E., *see* Crescent City Water Co.

Odom, C. R., City Mgr., Bartow, Fla. (Oct. '49) *M*

Olsen, Frederick J., Public Health Engr., Bureau of Public Health Eng., Board of Health, Washington, D.C. (Oct. '49) *P*

Otts, Louis E., Jr., Assoc. Prof. of Civ. Eng., Univ. of Maryland, College Park, Md. (Oct. '49) *M*

Overstreet, Cecil C., City Engr., Prescott, Ariz. (Oct. '49)

Pajakowski, Casimir J., *see* South Bend Water Works

Parker, Florence D. (Mrs.), Secy., Yost & Gardner, Cons. Engrs., 508 Heard Bldg., Phoenix, Ariz. (Oct. '49)

Pelon, Guy, Supt., Water Dist. No. 2, Indian Lake, N.Y. (Oct. '49) *MP*

Persily, Clemens C., *see* Reiner, John, & Co.

Pratt, Joe C., *see* Shreveport Dept. of Water & Sewerage

Reese, Merle C., Div. Auditor, California Water & Telephone Co., 481 Tyler St., Monterey, Calif. (Oct. '49) *M*

Reiner, John, & Co., Clemens C. Persily, 21-34 Broadway, Long Island City 6, N.Y. (Assoc. M. Oct. '49)

Rekerdre, George T., Owner & Operator, Palomar Water System & Delray Water System, 4150 Camino de la Colina, Tucson, Ariz. (Oct. '49) *M*

Revell, Rufus Benjamin, Water Chemist, State Hospital, c/o Eng. Dept., Chattahoochee, Fla. (Jr. M. Oct. '49)

Rogers, Lincoln F., Foreman, Meter Dept., Water Dept., 1612 E. Wardlow Rd., Long Beach, Calif. (Oct. '49) *M*

Rowe, Joseph A., Civ. Engr. & Partner, W. P. Rowe & Son, 736 G St., San Bernardino, Calif. (Oct. '49)

Rowe, W. P., Partner, W. P. Rowe & Son, 3 Evans Bldg., Riverside, Calif. (Oct. '49)

Seekell, S. C., *see* Wolverine Tube Div.

(Continued on page 34)

HOW LONG is a water line?

Measure it in labor time, and you'll discover that any water supply or force main is shorter when you use ARMCO Welded Steel Pipe.

That's because ARMCO Pipe is so easy to handle and install. The whole job goes faster, smoother and more profitably. Lengths up to 50 feet mean fewer joints—there are just 106 in a mile. Even these go together quickly using standard couplers or by field welding.

You can use ARMCO Steel Pipe with complete confidence. It has a high safety factor against internal or external pressures. And the patented method of manufacture permits visual inspection of both sides of the pipe wall to guard against flaws. A spun-enamel lining assures continued high flow capacity, prevents tuberculation, stops costly cleaning.

With ARMCO Steel Pipe you can match exact job requirements—save time, labor and money. Diameters range from 6 to 36 inches; wall thicknesses from 9/64- to 1/2-inch. Write for complete data. Armco Drainage & Metal Products, Inc., Welded Pipe Sales Division, 1205 Curtis St., Middletown, Ohio.

ARMCO WELDED STEEL PIPE

CONTROL

RESIDUAL CHLORINE

CHLORINE is indispensable in the purifying of municipal water. Necessary, also, is the conditioning of this water for drinking purposes by the use of an effective antichlor, to make it more pleasant-tasting.

Superintendents and engineers of well managed plants make routine use of "Virginia" liquid Sulfur Dioxide ("Esotoo") in their filtering installations. They know, from experience, that "Esotoo" provides that accurate and positive control of residual chlorine which is so essential to palatable drinking water.

Our technical staff is at your service in solving this problem. Write to us for full information about "Esotoo" (SO_2) as a dechlor. Virginia Smelting Company, West Norfolk, Virginia.

50 YEARS OF SERVICE TO INDUSTRY

VIRGINIA

"Esotoo"

The preferred dechlor

WEST NORFOLK • NEW YORK • BOSTON • DETROIT

(Continued from page 32)

Shanklin, George R., Asst. Chief Engr., Div. of Water Policy & Supply, State Dept. of Conservation & Economic Development, 28 W. State St., Trenton, N.J. (Oct. '49)

Sherrill, Miles O., San. Engr., Maurice L. Miller, Cons. Engr., Louisville, Ky. (Oct. '49) *MP*

Shreveport Dept. of Water & Sewerage, Joe C. Pratt, Comr. of Public Utilities, City Hall, Shreveport, La. (Corp. M. Oct. '49)

Siewert, Edmund E., *see* Florida Utilities Corp.

Smith, Alphonsus P., Jr. Asst. Supt. Bureau of Water Supply, Baltimore, Md. (Oct. '49) *M*

South Bend Water Works, Casimir J. Pajakowski, Supt., 224 N. Main St., South Bend, Ind. (Corp. M. Oct. '49)

Spencer, Merlin Glen, Eng. Aid, Water Dept., 215 W. Broadway, Long Beach, Calif. (Oct. '49) *M*

Stevenson, Robert, Water Supt., Fontana, Wis. (Oct. '49)

Strand, J. A., Partner, Ward & Strand, 1 W. Main St., Madison, Wis. (Oct. '49)

Sullivan, Clarence Rowe, Partner, Sullivan Mfg. Co., 2114 W. Monte Vista, Phoenix, Ariz. (Oct. '49) *M*

Sutherland, Roy E., Asst. Engr., State Public Utilities Com., 1813 W. Alameda Ave., Burbank, Calif. (Oct. '49) *M*

Turner, Clifford R., Service Engr., Electric Chemical Co., 1915 Broad St., Paducah, Ky. (Oct. '49) *P*

Turpin, Owen W., Cons. Engr., Turpin, Wachter & Assoc., 1004 N. Charles St., Baltimore, Md. (Oct. '49) *P*

Walker, James Frederick, Jr., Water Treatment Operator, United States Sugar Corp., Clewiston, Fla. (Oct. '49) *P*

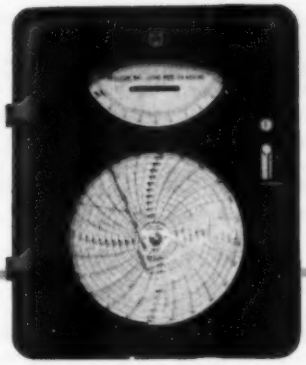
Warren, Kenneth Raymond, Chief Accountant, Water Dept., 205 N. Greenleaf Ave., Whittier, Calif. (Oct. '49) *M*

Watters, Clarence George, Jr., Engr. & Supt. of Operations, Carlsbad Mutual Water Co., Carlsbad, Calif. (Oct. '49) *M*

Welch, Marion Carlyle, San. Engr., Louisville-Jefferson County Board of Health, 240 E. Madison St., Louisville, Ky. (Oct. '49) *MPR*

(Continued on page 36)

Simplex narrows the gap of error



With New TYPE "H" METER

An extremely accurate meter which measures flows within ± 2% over a 13 to 1 range!

We feel that a discerning engineer requires accuracy above all else in any instrument he purchases. Within its flow range the new Type "H" Meter registers measurements that are more accurate than usually encountered in commercial instrumentation and it truly "narrows the gap of error".

Type "H" Meter is specially designed for:

- **Use with Venturi Tube, Flow Nozzle, or Orifice Plate.**
- **Measurement of hot or cold water, steam, process liquors, gases, trade wastes, sewage or sludge.**
- **Wall bracket, instrument panel, or floor mounting . . . outdoor or indoor as desired.**
- **Inclusion of three vital measuring elements—indicator, recorder, totalizer.**
- **Testing in place at any time with an easily applied manometer test device.**
- **Maximum differentials of 114" or 64" of water as desired.**
- **Easy flow reading, utilizing evenly spaced chart and dial graduations.**

IT'S ACCURATE
IT'S SIMPLEX

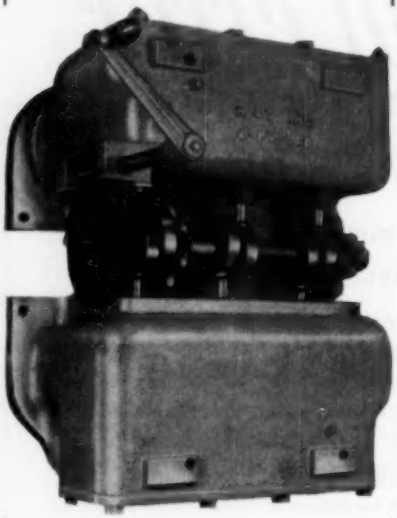
Write for Free Bulletin No. 400 to the Simplex Valve & Meter Co., Dept. 1, 6784 Upland St., Philadelphia 42, Pa.

SIMPLEX

VALVE AND METER COMPANY

SOFT WATER?
Yes—but

When you buy any zeolite water softener—manual, semi-automatic or fully automatic—insist that it be equipped with an H & T poppet type multiport valve.



This valve, built in all sizes and for all requirements, is a masterpiece of workmanship and operating simplicity. It is available only to experienced water softener manufacturers.

Designed, built and guaranteed by

HUNGERFORD & TERRY, INC.
Clayton, New Jersey

(*Continued from page 34*)

Wertz, R. D., Dist. Repr., R. D. Wood Co., 113 S. Federal Highway, Lake Worth, Fla. (Oct. '49)

Wolverine Tube Div., S. C. Seekell, Salesman, 1411 Central Ave., Detroit 9, Mich. (Assoc. M. Oct. '49)

REINSTATEMENTS

Caspar, City of, Tom Jessen, Mayor & Water Comr., City County Bldg., Caspar, Wyo. (Corp. M. Oct. '37)

Jessen, Tom, *see* Caspar, City of

Wenrick, H. P., Contractor & Engr., Wenrick & Assoc., 4015 Pacific Blvd., San Mateo, Calif. (Oct. '38) *M*

LOSSES

Deaths

Currens, Warren W., Supt. of Filtration, Passaic Valley Water Commission, Box 268, Little Falls, N.J. (Jan. '39) *MPR*

Estabrook, Joseph B., Pres., Hitchcock & Estabrook, Inc., Cons. Engrs., 521 Sexton Bldg., Minneapolis 15, Minn. (Apr. '36) *P*

Fenkell, George H., Almont, Mich. (June '20) *Trustee '26–'28. Vice-Pres. '30. President '31. Director '31–'32, '38–'41. Honorary M. '40.*

Findlan, John S., Commissioner of Finance, Dept. of Finance, St. Paul, Minn. (Oct. '38)

Hechmer, Carl A., Dept. Engr., Maint. & Operation Dept., Washington Suburban San. Dist., 4017 Hamilton St., Hyattsville, Md. (Nov. '19) *Fuller Award '40. Director '48–'51. MP*

Hoover, Clarence B., Gen. Supt., Div. of Water, City Hall, Columbus, Ohio (Apr. '23)

Isaacson, Claude N., Repr., Water Works Supply Co., 448 S. Hill St., Los Angeles 13, Calif. (Jan. '43) *R*

Jordan, Henri K., Pres., Canada Valve & Hydrant Co., Ltd., Brantford, Ont. (July '41) *M*

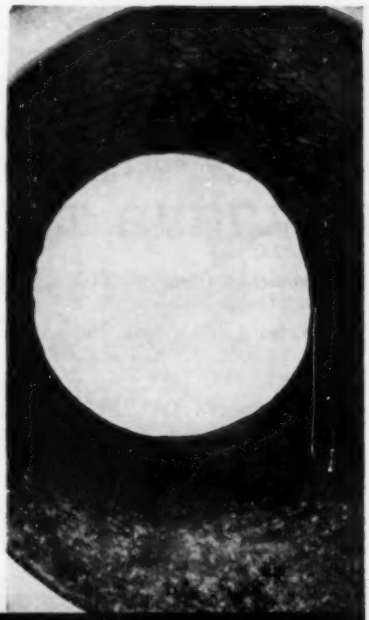
Klein, William I., Cons. Engr., 21 Maple Terrace, East Orange, N.J. (July '13)

Ward, Clayton N., Sr. Partner, Ward & Strand, 1 W. Main St., Madison, Wis. (June '30) *PR*

(*Continued on page 38*)

With seven miles of badly corroded 36" and 48" steel pipe up for replacement at an estimated cost of $1,800,000., the City of Montreal reconditioned the entire line at a total cost of only $205,000. — a saving of $1,595,000.

Reconditioning included a thorough cleaning and removal of incrustation and debris by the National Water Main Cleaning Co. after which the cleaned surface was centrilined. Final results indicate reduced friction losses, improved carrying capacity and permanent protection against leakage and internal corrosion.



cleaning and reconditioning water main
SAVES MONTREAL $1,595,000

Why not let our engineers find out if similar savings can be effected in your city? No obligation of course!

25

NATIONAL WATER MAIN CLEANING CO.

50 CHURCH STREET, NEW YORK 7, N. Y.

ATLANTA, GA., 1221 Mortgage Guarantee Bldg. & P.O. Box 9—Station E • BOSTON, 115 Peterboro St. • CHICAGO, Room 1336, S. Michigan Ave. • KANSAS CITY, 421 BMA Building • LOS ANGELES, 448 S. Hill Street • LITTLE FALLS, N. J., Box 91 • OMAHA, 3812 Castellar Street • RICHMOND, 210 East Franklin Street • SPRINGFIELD, MO., 1301 Prospect Ave. • SALT LAKE CITY, 149-151 W. Second So. St. • SAN FRANCISCO, 681 Market St. • SIGNAL MT., TENN., 204 Slayton Street • FLANDREAU, S. D., 315 No. Crescent St. • MONTREAL, 2028 Union Avenue • VANCOUVER, B.C., 505 West 1st Avenue • WACO, P. O. Box 887 • WINNIPEG, 576 Wall St. • HAVANA • SAN JUAN, PUERTO RICO • BOGOTA • CARACAS • MEXICO CITY.

(Continued from page 36)

CHANGES IN ADDRESS

Changes received between November 5 and December 5, 1949

Aluminum Co. of America, P.O. No. 420972, Massena, N.Y. (Corp. M. July '47)

Barton, Harry, Box 505, Great Neck, N.Y. (Dec. '28) *M*

Bethencourt, Daniel, Humbold 151, Vedado, Havana, Cuba (Jan. '49)

Bready, Ira J., Dist. Mgr., Liquid Conditioning Corp., 3119 Griest, Cincinnati 8, Ohio (Jan. '38) *P*

Carroll, John J., Dist. Mgr., Neptune Meter Co., 815 W. Market St., Louisville 2, Ky. (Jan. '38) *M*

Cleary, Edward J., Exec. Director & Chief Engr., Ohio River Valley San. Com., 414 Walnut St., Cincinnati 2, Ohio (Jan. '45)

Collie, R. M., 7426 Magnolia, Houston 12, Tex. (Oct. '48)

Corin, Magnus F., 214—3rd St., Beach Haven, N.J. (Apr. '10) *P*

Cranch, Eugene T., International City Managers' Assn., 1313 E. 60th St., Chicago 37, Ill. (Mar. '22) *M*

Fryer, Colin J., Dearborn Chemical Co., 941 Waumanu St., Honolulu, Hawaii (Oct. '45) *P*

Ghiotto, Louis A., 946 Victoria Drive, Arcadia, Calif. (Apr. '36)

Hall, Howard W., Cons. Engr., 702 W. 11th St., Corona, Calif. (Jan. '48)

Haydock, Charles, Cons. Engr., 2314 Girard Trust Co. Bldg., Philadelphia 2, Pa. (Feb. '19)

Horstmann, F. B., 428 Uvedale Road, Riverside, Ill. (June '27) *P*

Filter Sand and Gravel

WELL WASHED AND CAREFULLY GRADED TO ANY SPECIFICATION.
PROMPT SHIPMENT IN BULK OR IN BAGS OF 100 LB. EACH.

Inquiries Solicited

Northern Gravel Co.
P. O. Box 307, Muscatine, Iowa

Hulbert, Roberts, 680 W. Brown St., Birmingham, Mich. (Apr. '30) *Fuller Award '42. P*

Johnson, Francis M., Lt. Col., USAF (MSC), c/o Air Surgeon, Headquarters Air Training Command, Scott Air Force Base, Ill. (Oct. '37)

King, Kenneth, 4971 Ward Pkwy., Kansas City 2, Mo. (July '40) *M*

Kopp, Joseph P., Sewage Plant Operator, 10630 Helena Ave., Cleveland 8, Ohio (Oct. '44) *MP*

Leary, Charles J., Route 4, Greenfield, Ind. (Oct. '45)

Longwell, John S., 21 King Ave., Piedmont 11, Calif. (Oct. '31) *Director '42–'45.*

Nelson, Fred B., 26770 Lorain Rd., North Olmsted, Ohio (July '07) *M*

Niles, Philip B., Yale & Towne Mfg. Co., 405 Lexington Ave., New York 17, N.Y. (Jan. '48)

O'Reilly, Don, *Speed Age,* Professional Bldg., Hyattsville, Md. (July '48)

Papineau, Marcel, 11366 Plaza, Montreal, Que. (Apr. '49)

Patton, C. S., 103 Park Ave., New York 17, N.Y. (May '30)

Richards, John Raymond, Box 4696, Anacostia, Va. (Apr. '49) *P*

Schoonmaker, George N., Jones, Henry & Schoonmaker, 821 Security Bldg., Toledo 4, Ohio (Aug. '21)

Skibbe, Henry E., Box 453, Oshkosh, Wis. (Oct. '45)

Spalding, George R., 10 Meadow Lane, New Canaan, Conn. (June '26) *Fuller Award '41. MP*

Suryaprakasam, M. V., San. Eng. Dept., Johns Hopkins Univ., Baltimore 18, Md. (July '49)

Towne, W. W., U.S. Public Health Service, 1014–20 Broadway, Cincinnati 2, Ohio (Dec. '29) *P*

Wagner, Richard F., City Hall, Lynchburg, Va. (Nov. '19)

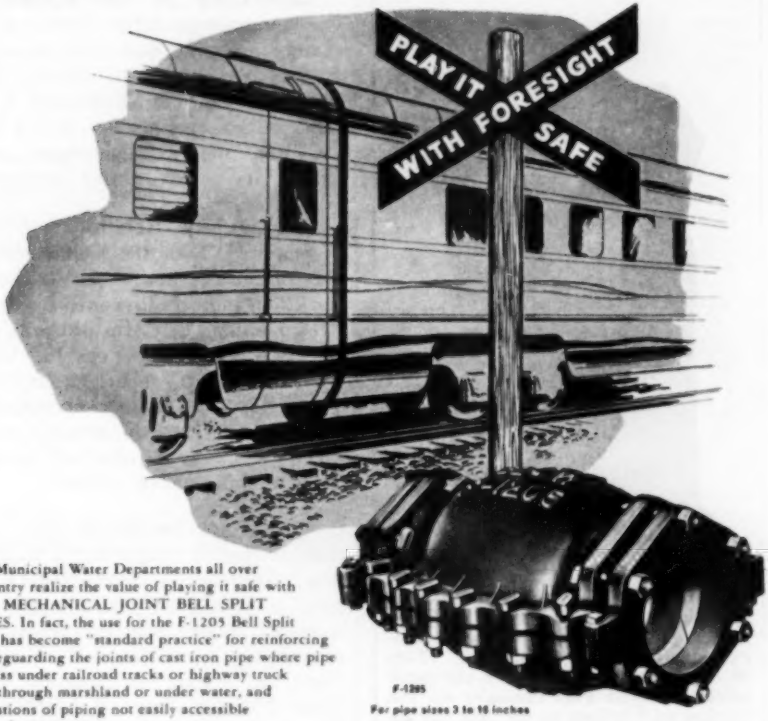
Whyman, Lucy T. (Mrs.), Owner & Mgr., Whyman Water Works, Box 306, Tolleson, Ariz. (Jan. '48)

Yoder, M. Carleton, San. Engr., 1009 Hook Ave., Concord, Calif. (Jan. '49)

Young, Lewis A., U.S. Public Health Service, Southeast Drainage Basins Office, 114 Marietta St., Atlanta, Ga. (Oct. '48)

Where the pressure's on – reinforce and protect all joints of cast iron pipe with

CLOW BELL SPLIT SLEEVES

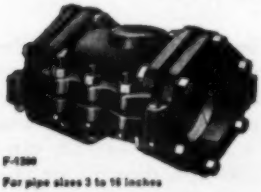


Today Municipal Water Departments all over the country realize the value of playing it safe with CLOW MECHANICAL JOINT BELL SPLIT SLEEVES. In fact, the use for the F-1205 Bell Split Sleeves has become "standard practice" for reinforcing and safeguarding the joints of cast iron pipe where pipe lines pass under railroad tracks or highway truck routes, through marshland or under water, and any locations of piping not easily accessible in case of emergency.

F-1205
For pipe sizes 3 to 16 inches

No Lead . . . No Jute . . . No Calking

Write for completely illustrated descriptive circular



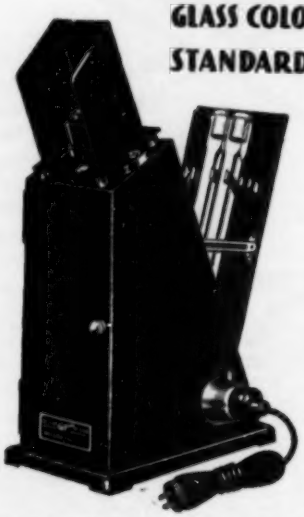
F-1200
For pipe sizes 3 to 16 inches

JAMES B. CLOW & SONS
201-299 North Talman Avenue • Chicago 80, Illinois
and their National Cast Iron Pipe Division, Birmingham, Ala.; subsidiaries Eddy Valve Co., Waterford, N. Y.; Iowa Valve Co., Oskaloosa, Ia.

Make repairs to pipe barrel with F-1200 Clow Mechanical Joint Straight Split Sleeves. Sizes 12-inch and smaller will repair length-wise breaks up to 8 inches; sizes 14-inch and 16-inch, up to 17 inches.

HELLIGE Aqua TESTER

EMPLOYING
NON-FADING GLASS COLOR STANDARDS



THE HELLIGE AQUA TESTER combines the advantages of non-fading glass color standards with radical improvements in design. This Water Tester is, we believe, the most advanced type ever brought on the market and brings to its user the utmost in accuracy, permanent reliability, and ease of operation.

Glass Color Standards based on A.P.H.A. and A.W.W.A. methods are available for Color of Water, Ammonia Nitrogen, Nitrite Nitrogen, Nitrate Nitrogen, Chlorine, Iron, Dissolved Oxygen, Manganese, Lead, Phosphate, Silica, Sulphides and Hydrogen Ion Measurements.

Write for Bulletin No. 602

HELLIGE
INCORPORATED
3718 NORTHERN BLVD.
LONG ISLAND CITY 1, N.Y.

Service Lines

Laboratory jar test stirrers for conducting coagulation tests on raw waters are described in a four-page folder available from Stuart Corp., 516 N. Charles St., Baltimore 1, Md. The units accommodate six 1-l beakers and include tachometer, timer switch and speed control rheostat.

"Community Relations: Getting Acquainted With the Community" is the title of a new report issued by the Policyholders Service Bureau of Metropolitan Life Insurance Co., 1 Madison Ave., New York 10. Copies of this "how-to" report on improving public relations through accepting the social obligations of industry to the community may be obtained from the bureau at the above address.

"Industrial Sanitation in a Municipal Health Program," a paper by Prof. William T. Ingram which outlines a procedure for a cooperative approach to the problem, is available as a 2-page reprint from V. W. Palen, Bur. of Public Information, New York Univ. College of Engineering, New York 53. To cover handling and mailing costs, 10¢ should be enclosed. The article was originally published in *Modern Sanitation* for August.

A compact chemical feeder of transparent acrylic plastic is described in Catalog 62 of the Fischer & Porter Co., Hatboro, Pa. The unit, which is only $10 \times 5 \times 2$ in. overall, can treat up to 7,000 gpd. directly, or utilizing a bypass arrangement and dispensing a 5 per cent solution of the chemical, it can add 5 ppm. to over 14 mgd.

(Continued on page 42)

WORTHINGTON-GAMON

WATCH DOG

WATER METERS

The meter used by thousands of municipalities in the U. S.

"Watch Dog" models . . . made in standard capacities from 20 g.p.m. up: frost-proof and split case in household sizes. Disc, turbine, or compound type.

SURE TO MEET YOUR SPECIFICATIONS FOR ACCURACY, LOW MAINTENANCE, LONG LIFE.

Before you invest in water meters, get acquainted with the design and performance advantages which make Worthington-Gamon Watch Dog Water Meters first choice of so many municipalities and private water companies in the United States.

WORTHINGTON-GAMON METER CO.

296 South Street, Newark 5, New Jersey

SUBSIDIARY OF

WORTHINGTON

WORTHINGTON PUMP AND MACHINERY CORPORATION

APPROVED
by UNDERWRITERS' LABORATORIES, Inc.

GREENBERG
Independently Valved HYDRANTS
for non-freezing climates

Western water works engineers and fire chiefs were the first to approve Greenberg California-type fire hydrants. Now, after exhaustive tests, Underwriters' Laboratories, Inc. has confirmed your judgment.

Greenberg No. 74 and 76 hydrants are equipped with independent valves of a new type which open quickly and easily, allowing full flow with minimum resistance. They close tightly without water hammer. A major improvement over the old "cork in bottle" type valve!

Other innovations such as you would expect of the people who evolved the California-type hydrant 75 years ago are shown in the free booklet "Hydrants by Greenberg." May we send you a copy?

STABILITY since 1854

BRONZE PRODUCTS
GREENBERG

M. GREENBERG'S SONS
765 Folsom St • San Francisco • Calif • EXbrook 2-3144
Los Angeles • Seattle • Portland • Salt Lake City • Denver
El Paso • New York • Hartford • Washington, D.C.

(*Continued from page 40*)

"The Story of the Chemicals You Live By" is a 16-page, nontechnical exposition of the production and uses of such familiar chemical products of the Diamond Alkali Co. as chlorine, soda ash and silicate of soda. As a primer it may offer information of public relations use, especially for educational purposes. Copies are obtainable from district sales offices, or from Diamond's central headquarters, 300 Union Commerce Bldg., Cleveland 14, Ohio.

A water softener utilizing a cold process, slurry type precipitator and coagulator is described in Bul. W–212–B5 of Worthington Pump & Machinery Corp., Water Treating Section, Dunellen, N. J. The device avoids the use of submerged mechanical moving parts by employing hydraulic energy to mix the applied chemicals with previously formed precipitates.

Industrial waste and sewage treatment is the subject of a 24-page manual, No. 149, published by American Well Works, Aurora, Ill. Entitled "Modern Processes and Equipment for Sewage and Industrial Waste Treatment," the indexed booklet includes sections on aeration, sedimentation, pretreatment, industrial waste treatment and recovery, and related topics.

The "Walking Beam" flocculator is the subject of a circular distributed by Stuart Corp., 516 N. Charles St., Baltimore 1, Md.

FIGHT INFANTILE PARALYSIS

JOIN THE MARCH OF DIMES

THE NATIONAL FOUNDATION FOR INFANTILE PARALYSIS

CHECK YOUR REQUIREMENTS

with these advantages of Reinforced Concrete Cylinder Pipe for main water transmission lines

1. Combines the physical strength and characteristics of steel with protective features and permanency of well-made concrete.

2. Under normal bedding and backfill conditions, will successfully withstand external or trench loads up to 10 ft. of cover. Greater loads are safely provided for by compacted backfill, cradling or additional steel reinforcement.

3. Has ample strength for the occasional concentrated loading which is sometimes met in practice.

4. Will remain water tight under conditions of foundation settlement or soil movement within the limits generally met in water works practice.

5. Has a long life with freedom from corrosion or deterioration. Concrete encasement protects steel cylinder and reinforcement from electrolytic action and deleterious ground water.

6. Conservative design basis and assumed unit stress of this class of pipe allow ample factor of safety for all normal conditions of service including surge and water hammer.

7. In event of earthquake, sudden or extreme increases of pressure, or other disturbances, pipe will neither burst, shatter, nor discharge its full flow of water.

8. If surges beyond design operating limit, or other extraordinary pressures cause cracks to open up in concrete lining or encasement, they will close and seal after these heavy pressures have been relieved, wherever elastic limit of steel has not been exceeded.

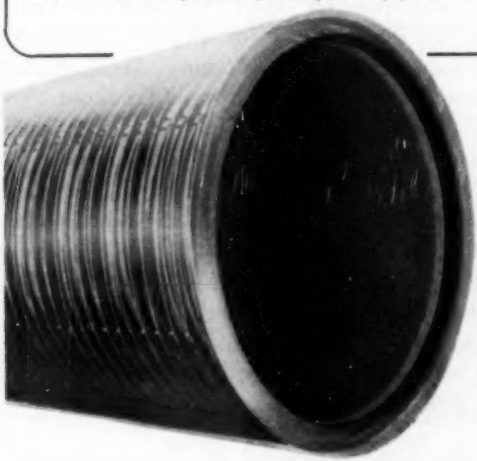
9. Rugged construction provides ample strength to withstand all normal handling conditions.

Complete information is available upon request

American PIPE AND CONSTRUCTION CO.

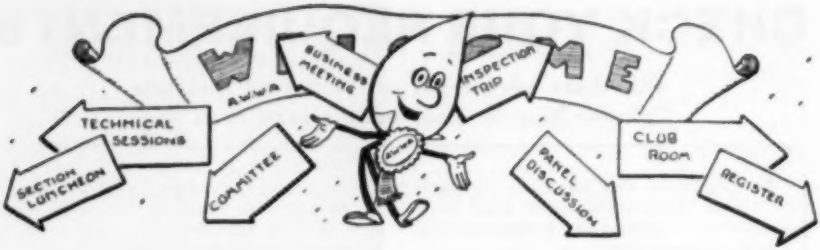
Concrete pipe for main water supply lines, storm & sanitary sewers, subaqueous pipe lines

P.O. Box 3428, Terminal Annex, Los Angeles 54, Calif. Main Offices and Plant - 4635 Firestone Boulevard, South Gate, California. District Sales Offices and Plants - Oakland - San Diego - Portland, Oregon



COMBINES strength of STEEL with permanency of CONCRETE

Available in three types to meet the requirements of pressure transmission of water: American Concrete Cylinder Pipe, Lock Joint Concrete Cylinder Pipe (non-prestressed), and Lock Joint Prestressed Concrete Cylinder Pipe. All employ the Lock Joint Rubber Gasket Joint type of closure Phantom view shows how steel cylinder and reinforcement cages are encased in concrete wall of 57" Lock Joint Cylinder Pipe, non-prestressed.



Section Meeting Reports

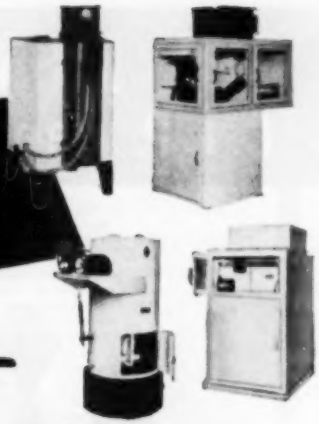
Southwest Section: The Southwest Section held its thirty-eighth annual meeting in Oklahoma City, October 10–12, with M. B. Cunningham, superintendent and engineer of the Oklahoma City Water Dept. serving as host. Registration reached a record 618.

The technical sessions, to which three full days were devoted, were well attended. A complete description of the Oklahoma City Water Works System was presented by Cunningham and his entire staff. Panel discussions were a feature of the program, and the one on stream pollution was divided into several subtopics. "Financing" was treated by W. H. Sindt, division engineer, F.W.A., Bureau of Community Facilities, Fort Worth, Tex.; "National Aspects," by Carl Warkentin, officer in charge, Div. of Water Pollution Control, Little Rock, Ark.; and "State Aspects," by Dr. G. F. Mathews, State Dept. of Health, and Guy B. Treat, consulting engineer, both of Oklahoma City, Okla.

The panel on "Wells and A.W.W.A. Specifications" was handled by Dr. Stuart Schoff, district geologist of the Geological Survey at Norman, Okla., who discussed "Geology"; A. O. Fabrin, chief engineer with Layne & Bowler Co., Memphis, Tenn., who spoke on "Well Pump Column Life"; Compere Loveless, manager of the Pump & Electric Dept. of Fairbanks, Morse & Co., Kansas City, Mo., who discussed "Pumps"; G. E. Hauer, chief engineer for the American Wells Works, Aurora, Ill., whose topic was "Iron and Carbon Dioxide Removal"; and John P. Kleber, sales engineer with Calgon, Inc., Pittsburgh, Pa., who spoke on "Well Cleaning."

"Use of Radio for Water Departments" was treated by C. H. Sutter, chairman of the Mid-Central Utilities Radio Committee, and Grant Landon, superintendent of signals and alarms, Oklahoma City Fire Dept., after which an automobile was rolled into the auditorium for a demonstration. The subject of "Water Distribution System Problems" was discussed by H. G. Freehauf, Dept. of Utilities, Miami, Okla.; S. L. Perry, Water Dept., Alexandria, La.; Elmwood J. Umbenhauer, El Paso, Tex.; and W. K. Van Zandt, Water Dept., Houston, Tex.

(*Continued on page 48*)



WHEN IT COMES TO *FEEDERS*

Come to

OMEGA

BELT-TYPE GRAVIMETRIC FEEDERS Highly accurate and adaptable, for rates from 10 to 10,000 lbs. per hr.

LOSS-IN-WEIGHT GRAVIMETRIC FEEDERS Tops in accuracy. Sizes for feeding from ½ to 5,000 lbs. per hr.

UNIVERSAL FEEDERS Simple, dependable feeders for dry materials. Capacities: 1 to 5,000 lbs. per hr.

PRECISION SOLUTION FEEDERS Feed liquids by gravity. No valves, pumps, diaphragms. Available for rates from .08 to 500 g.p.h.

DISC FEEDERS For fine, dry materials. Two models for rates from ½ oz. per hr. to 200 lbs. per hr.

ROTODIP SOLUTION FEEDER Meters and feeds liquids at rates up to 800 g.p.h.

ROTOLOCK FEEDERS Volumetric dry feeders, with capacities to 300 cu. ft. per hr.

LIME SLAKERS Designed for water and sewage plants. Capacities from 175 to 10,000 lbs. per hr.

LABORATORY STIRRERS Six paddle units for laboratory coagulation tests.

Also Dust Collectors and Chemical Elevators for use with the above chemical feeders.

Write for Bulletins and engineering information. Address Omega Machine Company (Division of Builders Iron Foundry), Providence 1, Rhode Island.

THE LAST WORD IN FEEDERS

OMEGA

THE MEMBERSHIP OF A C.I.P. Century Club now has

The Cast Iron Pipe Century Club is probably the most unique club in the world. Membership is limited to municipal, or privately-owned, gas and water supply systems having cast iron mains in service for a century or more.

Although the Club is formally established, there are no dues, no regular meetings, and no obligations other than to inform the Recording Secretary if and when the qualifying gas or water main is taken out of service, or, sold for re-use.

CAST IRON PIPE

DISTINGUISHED CLUB...
29 Members!

In spite of the unique requirement for membership, the Club roster grows, year by year. And why not, when answers to a questionnaire, mailed to gas officials in 43 large cities, show that *original* cast iron mains are still in service in 29 of the cities. And a survey sponsored by three water works associations, indicates that 96% of all 6-inch and larger cast iron water mains ever laid in 25 representative cities are still in service.

If your records show a cast iron main in service, laid a century or more ago, the Club invites you to send for a handsome framed Certificate of Honorary Membership. Address Thomas F. Wolfe, Recording Secretary, Cast Iron Pipe Century Club, Peoples Gas Bldg., Chicago 3, Illinois.

CLUB ROSTER

BUREAU OF WATER, DEPT. OF PUBLIC WORKS
Baltimore, Maryland

CONSOLIDATED GAS ELECTRIC LIGHT & POWER CO.
Baltimore, Maryland

PUBLIC WORKS DEPT., WATER DIVISION
Boston, Massachusetts

BOSTON CONSOLIDATED GAS CO.
Boston, Massachusetts

BOARD OF WATER COMMISSIONERS
Detroit, Michigan

FALL RIVER GAS WORKS COMPANY
Fall River, Massachusetts

CITY OF FREDERICK WATER DEPT.
Frederick, Maryland

THE HARTFORD GAS COMPANY
Hartford, Connecticut

BUREAU OF WATER
Lancaster, Pennsylvania

LOUISVILLE GAS & ELECTRIC CO.
Louisville, Kentucky

CITY OF LYNCHBURG WATER DEPARTMENT
Lynchburg, Virginia

MOBILE GAS SERVICE CORP.
Mobile, Alabama

MOBILE WATER WORKS COMPANY
Mobile, Alabama

NEW ORLEANS PUBLIC SERVICE, INC.
New Orleans, Louisiana

PUBLIC SERVICE ELECTRIC & GAS COMPANY
Newark, New Jersey

DEPT. OF WATER, GAS & ELECTRICITY
New York, New York

DEPT. OF PUBLIC WORKS, BUREAU OF WATER
Philadelphia, Pennsylvania

PHILADELPHIA GAS WORKS CO.
Philadelphia, Pennsylvania

QUEBEC POWER COMPANY, GAS DIVISION
Quebec, Canada

BUREAU OF WATER
Reading, Pennsylvania

DEPT. OF PUBLIC UTILITIES
Richmond, Virginia

WATER & SEWERAGE DEPARTMENT
City of Saint John, N. B.

DEPT. OF PUBLIC UTILITIES, WATER DIVISION
St. Louis, Missouri

THE CONSUMER'S GAS CO. OF TORONTO
Toronto, Ontario

DEPT. OF PUBLIC WORKS
Troy, New York

CITY OF UTICA, BOARD OF WATER SUPPLY
Utica, New York

CITY OF WHEELING WATER DEPT.
Wheeling, West Virginia

WILMINGTON WATER DEPT.
Wilmington, Delaware

YORK WATER COMPANY
York, Pennsylvania

SERVES FOR CENTURIES

(Continued from page 44)

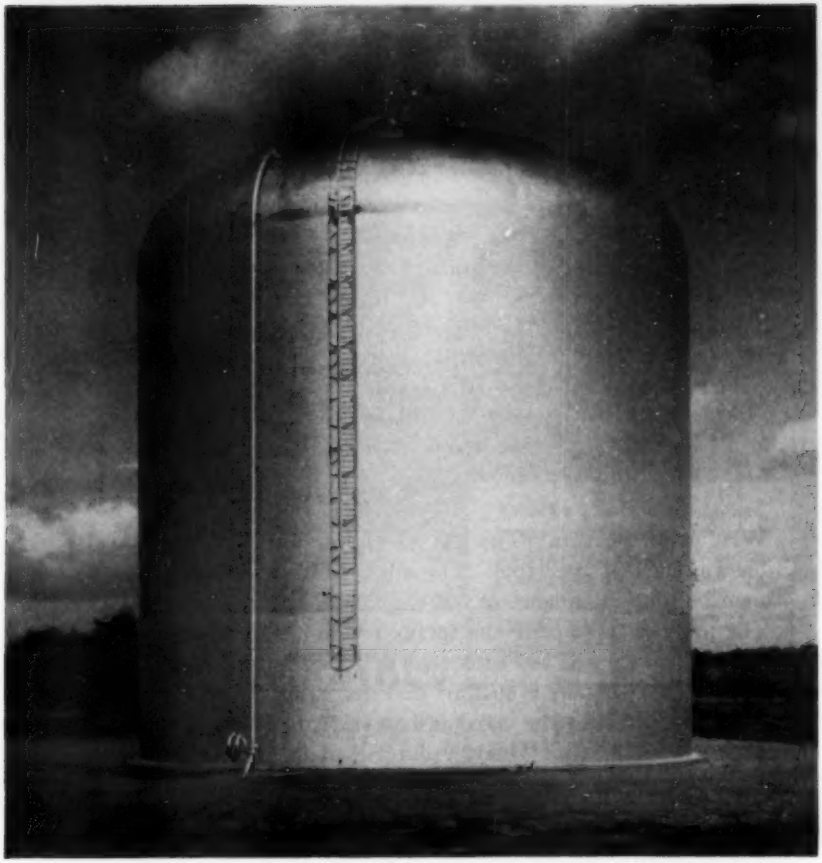
"Public Relations" was discussed by M. L. Powers, Okla. Institute of Technology, Stillwater, Okla. R. M. Dixon, managing director, Municipal Contractors Assn., Dallas, Tex., discussed "Wages," and Phil Rhoades, First National Bank & Trust Co., Oklahoma City, Okla., and F. G. Baker, auditor for Oklahoma City, Okla., spoke on "Bonds."

"Latest Methods of Chlorination and Testing" was treated by N. S. Chamberlin, sanitary chemist of the Wallace & Tiernan Co. Technical Service Div., Newark, N.J., and "Instruments and Controls for the Small

Filter Plant" was the subject of a talk by Everett M. Jones, vice-president of Simplex Valve & Meter Co., Philadelphia, Pa. L. C. Billings, chief chemist of water and sewage treatment at Dallas, Tex., spoke on "Water Softening" and the technical sessions were concluded by a paper on "Water Department Reports" presented by L. A. Jackson, manager-engineer of the Municipal Water Works, Little Rock, Ark., and G. O. Summers, city manager of Waxahachie, Tex.

At a colorful ceremony of the Kiowa tribe Monday night, Chief Jasper Saunkeah bestowed an Indian headdress and the name *Toa-Auh-Chon-Auh-Mau*, meaning "man who guides water" upon President Black (see cut). Vice-President Weir (right) was dubbed *Toa-Zole-Yah*, or "running

(Continued on page 50)



Welded Standpipe at Lansdale

The 1,250,000-gal. Horton standpipe shown here is an all-welded steel structure erected for the Lansdale Municipal Authority, Lansdale, Penna. A reserve supply of water of this kind helps to smooth out pressure fluctuations due to varying demand; bolsters pressure in areas remote from pumping station; relieves the pumps of peak loads by temporarily storing water pumped during slack periods and often justifies lower fire insurance premiums. Write our nearest office for information on standpipes or elevated water tanks.

CHICAGO BRIDGE & IRON COMPANY

BIRMINGHAM CHICAGO TULSA BOSTON SALT LAKE CITY
PHILADELPHIA NEW YORK DETROIT SEATTLE CLEVELAND
SAN FRANCISCO HOUSTON ATLANTA HAVANA LOS ANGELES

(*Continued from page 48*)

water." Both now head the tribe of Willing Water redmen, otherwise known as *Toa-Al-Om-Gah.*

Dean E. R. Stapley put on an unusually fine breakfast program, Wednesday morning, entitled "Radio Mystery" (direct broadcast). It was, as usual, one of Dr. Stapley's "nightmares." At the Wednesday noon luncheon, President Black presented the Section's Membership Cup for the first time to the winning state, Arkansas. At the Wednesday night banquet, Dr. Black spoke "off the cuff" in his usual winning manner and was applauded enthusiastically by over 500 registrants.

The meeting was climaxed Wednesday night by the presentation of the first Egmont S. Smith Memorial Scholarship Award to Miss Julia West of Lake Charles, La., daughter of George West, a Past-President of the Southwest Section.

L. A. JACKSON
Secretary-Treasurer

Wisconsin Section: The twenty-eighth meeting of the Wisconsin Section was held at the Hotel Schroeder, Milwaukee, on October 11–13, 1949, with a total attendance of 301.

The practice of starting the sessions with a movie was continued this year. This has worked out satisfactorily as it insures a full attendance at the time the first speaker is to start and decreases the confusion caused by people coming in after the speaker has started to talk. As usual, there were four sessions: the Distribution Session, Surface Water Session, Ground Water Session and General Session.

The Distribution Session was introduced October 11 by Milwaukee's Mayor, Frank P. Zeidler. The response was given by Chairman James A. Snow, who then turned the meeting over to the session chairman, Frank Quimby.

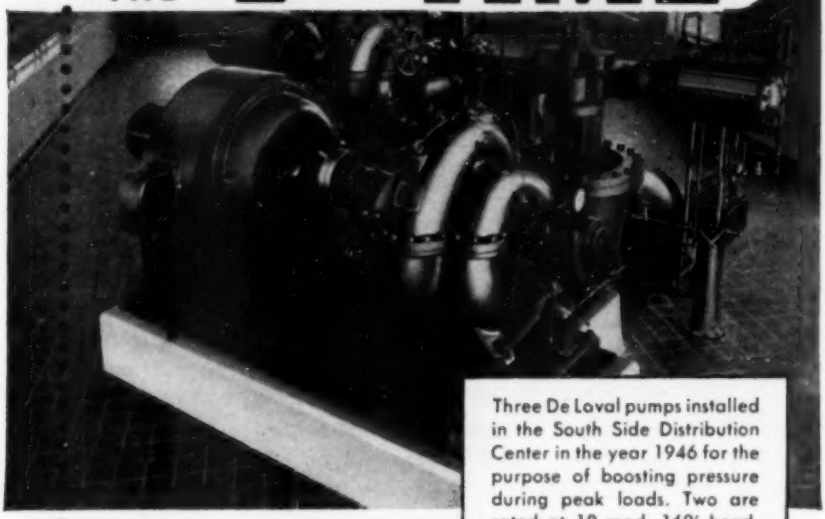
Joseph P. Schwada, city engineer of Milwaukee, presented the new A.W.W.A. specifications for the installation of cast iron water mains. He explained that the decision to omit mechanically jointed pipe from the specifications was made by the Water Works Practice Committee.

Eugene J. Voelker, of Tomaro Contractors, discussed the laying of water mains from the standpoint of the contractor. He called attention to the desirability of submitting as much information as possible about the underground conditions which would be found, as it would reduce the margin for contingencies which the contractor ordinarily includes in his bid.

C. N. Ward, who was to give a paper on "The Design of Water Distribution Systems," died about a week prior to the meeting, so that the time allowed for this paper was spent in a round-table discussion. A showing of hands was asked for, to ascertain the percentage of cities laying their own

(*Continued on page 52*)

FOR THE 7th TIME



Three De Laval pumps installed in the South Side Distribution Center in the year 1946 for the purpose of boosting pressure during peak loads. Two are rated at 10 mgd, 160′ head, the third at 15 mgd, 160′ head.

FLINT WILL INSTALL DE LAVAL PUMPS TO MEET INCREASED WATER DEMANDS

Seven times in a row . . . 1918, 1921, 1923, 1924, 1930, 1946, and now in 1949 the City of Flint, Michigan will install De Laval pumps to satisfy an ever increasing demand for water. Four low lift and two high lift pumps will be installed in Pumping Station No. 3 later this year and they will give the City of Flint a total capacity of 352 mgd . . . all handled by De Laval pumps.

Here, as in over 78 per cent of America's cities, De Laval pumps have insured complete dependability and high sustained efficiency, year after year. When you are ready to install additional pumping capacity, specify DE LAVAL.

Send for Catalog 10-8-JA

DE LAVAL

DE LAVAL STEAM TURBINE CO., TRENTON 2, N. J.

TURBINES • HELICAL GEARS • CENTRIFUGAL BLOWERS AND COMPRESSORS
CENTRIFUGAL PUMPS • WORM GEAR SPEED REDUCERS • IMO OIL PUMPS

WW-8

(Continued from page 50)

mains. Out of 38 represented, 21 cities laid their own mains and 17 had the work done by contractors; although many of those who had work done by contractors furnished the material. It was further found that the price for digging, laying and backfilling a 6-in. pipe varied from as low as 60 cents to $1.54 a foot.

The Surface Water Session was held on October 12 and presided over by Harold T. Rudgal. The first paper, entitled "The Electron Microscope and Its Possibilities in Control of Water Treatment," was presented by John R. Baylis of Chicago (*see* p. 66). The "Development of Water Works Pumping Equipment" was presented by Grant M. Hinkamp of Milwaukee. This paper described the various types of equipment for pumping water, starting with the older type of horizontal and vertical reciprocating steam pumps with simple, compound and triple expansion engines and including the steam and motor-driven centrifugals.

At a luncheon Wednesday noon, A.W.W.A. Secretary Harry Jordan gave a brief talk on standardization, and went on to suggest that the Wisconsin Section could increase its membership.

The Ground Water Session was held on October 12 and presided over by Arthur P. Kuranz. The program was the exact duplicate of the one prepared and presented at LaCrosse in 1948. At that time there was so much discussion from the floor when the session adjourned that both verbal and written requests were submitted to the officers and the Program Committee to repeat the program with the same papers and the same personnel. This was arranged, and W. J. Drescher's discussion was an extension of his remarks made in LaCrosse; briefly summarizing the work already done and bringing the record up to date with the additional work of the past year.

J. W. Gibb, civil engineer with the Milwaukee County Regional Planning Dept., discussed "Getting Water from the Ground," and his paper was the foundation for the panel discussion which followed. He clearly pointed

(Continued on page 54)

PALMER *Filter Bed* AGITATORS

Prevent Sand Beds From Cracking
Eliminate Mud Balls
Save Wash Water
Lengthen Filter Runs
Higher Rates of Filtration

FLOC-ALATORS ● CONVEYORS ● PALMER SURFACE WASH SYSTEMS
STUART CORPORATION, 516 N. Charles Street, Baltimore 1, Md.

HYDRO-TITE

JUST POUR

THAT'S ALL

Hydro-tite, the self-caulking, self-sealing, pipe-jointing compound, solidifies and hardens immediately without shrinkage. No caulking is necessary. Any slight seepage that may appear at first soon stops.

For over thirty years Hydro-tite has proved its ability to stand up under all conditions of strain, vibration and pressure. Send for data book and sample.

ALWAYS USE FIBREX

The sanitary, bacteria-free packing that costs about 30% less than braided jute. Send for sample.

HYDRAULIC DEVELOPMENT CORPORATION

Main Sales Office: 50 Church St. New York N. Y.

Factory and Main Office: Boston, Mass.

(*Continued from page 52*)

out the necessity of having a professional engineer who is thoroughly familiar with well drilling work draw up the specifications. He went on to enumerate the place that the State Geologists, the State Board of Health, the well drillers and the pump manufacturers play in the job of "Getting Water from the Ground."

The panel discussion which followed was participated in by E. F. Bean, State Geologist, who pointed out the assistance that the State Geological Survey could and was very willing to render to all those facing the problem of getting water from the ground and he urged professional engineers, municipalities, well drillers and all other parties interested in availing themselves of this service. H. E. Wirth, assistant sanitary engineer of the State Board of Health, explained very thoroughly the part the board could play in the proper development of both well specifications and the well itself.

Joe Egerer, well driller, provoked considerable thinking when he expressed the well drillers' viewpoint toward the well specifications and he cited in clear and certain terms the many points brought out in the specifications which were definitely unfair to the well drillers' profession

(*Continued on page 56*)

3 *Money, Time and Labor Saving Features of*

UNIVERSAL* CAST IRON PIPE

LAID WITH ONLY WRENCHES

NO CAULKING MATERIALS

NO GASKETS. NO BELL HOLES TO DIG.

*REG. U.S. PAT. OFF.

For water supply, fire protection systems, sewage disposal systems, industrial, and irrigation. Flexible.

Dept. C
THE CENTRAL FOUNDRY COMPANY
386 FOURTH AVENUE, NEW YORK 16, N. Y.

Gentlemen: Send us information and catalog on UNIVERSAL CAST IRON PIPE.

NAME_____

STREET_____

CITY_____

SPARLING
Main-Line Meters
for a
HAPPIER NEW YEAR

Sparling Meters on your pump and distribution lines point the way to keeping down production costs and improving service to your customers.

Bulletin 310 comes upon request

SPARLING
Manufacturers of WATER MEASURING EQUIPMENT

LOS ANGELES 54....Box 3277, Terminal Annex
CHICAGO 8.....1500 South Western Ave.
CINCINNATI 2.....622 Broadway
NEW YORK 17.....101 Park Avenue
BOSTON 8.....6 Beacon Street
SEATTLE 1.....1932 First Avenue
DALLAS 1.....726 Reserve Loan Life Bldg.

PRECISION CONTROL

WITH

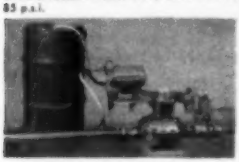
% PROPORTIONEERS %

Positive Displacement Proportioning Pumps

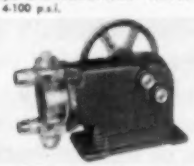
Diatomaceous Earth Filters

pH CONTROL
COAGULATION CONTROL
FILTRATION CONTROL
CORROSION CONTROL
ALGAE CONTROL
DECHLORINATION CONTROL
TASTE AND ODOR CONTROL
TOOTH DECAY CONTROL
ZEOLITE GENERATION CONTROL
BACTERIA CONTROL
RUST CONTROL
SEWAGE TREATMENT

FOR PUMPED WATER SYSTEMS
Constant Rate Feeder — Heavy Duty Midget Chem-O-Feeder. Feeds 0-7½ GPH at 0 to 85 p.s.i.



FOR VARIABLE FLOW SYSTEMS
Flow Proportional Feeder — Automatic and Proportional Chem-O-Feeder. Feeds 0-5 GPH at 4-100 p.s.i.



FOR YOUR CAMP Du-Self — a complete Package Unit—for water treating. For flows up to 25 GPM and 75 p.s.i.

FOR YOUR SWIM POOL For crystal clear swim pool water — Par-O-Cel Diatomaceous Earth Filter, Duplex Model.

NEW IMPROVED CHEM-O-FEEDER

MODEL 1-47

This new Heavy Duty Chem-O-Feeder has many added features for precision control and easier maintenance. Stroke length is instantly adjustable by turning a knob while pump is operating — a magnifying register glass shows exact reading in thousandths of an inch over a range from 2 to 13 cc per stroke. The new Model 1-47 has convenient oil fill and handy sight gauge — all moving parts operate in an oil bath. Plastic "See-thru" reagent head handles any chemical used in the water works field. Available in simplex, duplex and triplex models. Bulletin SAN-7.

With %Proportioneers% Equipment you can always maintain precision control in water purification and sewage treatment. Ask us for recommendations and quotations. Our experience from over 27,000 installations is at your service.

Write for Bulletins.

% PROPORTIONEERS, INC. %

Providence 1, R. I.

(Continued from page 54)

as he saw it; and that from his viewpoint, he would recommend that more attention be paid to the fairness in the interpretation of the work as the well drilling progresses. He took to task engineers and owners of wells who expected the well driller to take all of the responsibility, while the engineers and owners assumed little or none.

Mr. Nelson, of the J. P. Miller Artesian Well Company, expressed the viewpoint of the pump manufacturers and here again he criticized the position which engineers and owners take toward the material, feeling that some leeway should be allowed in meeting specifications. Considerable stress was placed upon the point concerning the straightness and plumbness of the hole in which a pump was to be placed.

Following this, a general discussion was in order and the floor responded genuinely and generously.

The entire session was briefly summarized by Oswald Muegge, State Sanitary Engineer, when he stressed very strongly the necessity of complete and thorough cooperation on a very free and mutual basis between all parties concerned. It was his feeling that if such a procedure were followed, much of the controversy which has been in evidence these many years would be minimized and, as a result, the ultimate owner (the customer) would receive the greatest benefit.

In all, the session was a success; it was well attended and great interest was displayed.

The General Session, which was devoted to the topic of rates, was held on October 13, and presided over by Thomas M. McGuire. Orville Deuel of the Wisconsin Public Service Commission presented a paper in which he outlined the procedures used by the commission in fixing rates. Preston A. Reynolds, rate analyst of Madison, discussed fire protection service charges, calling attention to the methods used in determining proper fire protection charges. A general discussion followed, largely centered around details of working out both general service and fire protection rates. Several of the cities in Wisconsin have had increases in water rates, with a minimum of objection on the part of the consumers because the increase in water rates, in general, is much less than the increase in other items of the customers' budget.

It was noted that at the last session of the legislature the cost of fluoridation of city water was, by statute, determined to be a utility charge and the Public Service Commission was directed to consider this in fixing rates in those cities which were treating the public supply with fluorine.

The banquet was held on Wednesday evening and was followed by a floor show. Approximately 250 were in attendance.

L. A. SMITH
Secretary-Treasurer

(Continued on page 58)

2 EASY WAYS to repair water lines

1

1. Clean pipe.

2. Measure with Dresser tape (packed with sleeve)

3. Fit sleeve sections on pipe.

4. Tighten bolts.

With a Dresser Repair Sleeve.

On cast iron pipe, 4" to 8" in diameter, for splits, breaks or holes, use a Dresser Style 82 "Adjustable" Repair Sleeve. One man can make a permanent repair in a matter of minutes, using only a wrench. Sleeve is factory-assembled; no loose parts, no gaskets to cut and fit when seconds count, no caulking. The specially compounded Dresser gaskets afford a quick pack—a permanent seal.

Note: The Dresser Style 82 Repair Sleeve also offers the most convenient method for making a large tap off a small diameter main.

2

1. 2. 3.

With Dresser Couplings. For breaks too long to be repaired with a sleeve, use Dresser Style 38 Couplings. Cut out a section of the pipe where the break occurs. Fit the couplings onto pipe ends. Put a new section in place. Bolt up the couplings. That's all there is to it. Dresser's resilient rubber gaskets assure a permanently tight repair . . . and guard against recurrence of the break by absorbing stresses and strains in the line.

Note: This same procedure can be followed for cutting a new line into an old one, for inserting a valve into a line and for solving similar problems.

DETAILED, FACTUAL LITERATURE on how Dresser products can solve your water line repair and coupling problems is yours for the asking. Write today.

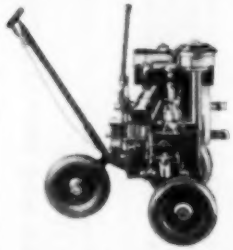
DRESSER COUPLINGS and REPAIR PRODUCTS

Dresser Manufacturing Division, 59 Fisher Ave., Bradford, Pa. (One of the Dresser Industries)
In Texas: 1121 Rothwell St., Houston • In Canada: 629 Adelaide St., W., Toronto
Sales offices: New York, Chicago, Houston, San Francisco

PIPE CLEANING TOOLS

FOR WATER LINES

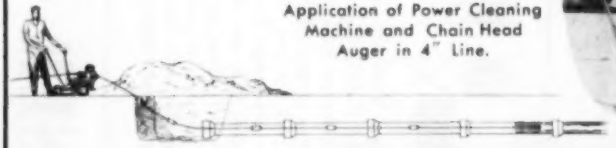
FOR SEWER LINES



Above "Flexible" Power Driven Pipe Cleaning Machine. Fast, Powerful, Safe.

Efficient Chain Head Cleaning Auger. A Power-Driven Tool.

"Flexible" Carry All Trailer, packs everything needed — Rod Reel, Steel Rods, Power Drive, etc.



Application of Power Cleaning Machine and Chain Head Auger in 4" Line.

...t a few minutes ...rk for Dodge ...ty to get at the Root of the trouble with "Flexibles."

"FLEXIBLE"

UNDERGROUND PIPE CLEANING CO. — **SEWER-ROD EQUIPMENT CO.**

9059 VENICE BOULEVARD, LOS ANGELES 34, CALIFORNIA

141 W. Jackson Blvd. Chicago, Ill.
401 Broadway New York 13
147 Hillside Ter. Irving, N. J.
P. O. Box 165 Atlanta
P. O. Box 465 Memphis, Tenn.
801 E. Excelsoir Blvd. Hopkins, Minn.
29 Cerdan Ave. Roslindale 31, Mass.
Box 167 Los Nietos, Calif.
41 Greenway St. Hamden, Conn.
3786 Durango Ave. Los Angeles 34, Calif.
709 House Bldg. Pittsburgh 8, Pa.
4455 S. E. 24th Ave. Portland 2, Ore.
P. O. Box 447 Lancaster, Texas

(Continued from page 56)

Alabama-Mississippi Section: The second annual meeting of the Alabama-Mississippi Section was held at the Heidelberg Hotel in Jackson, Miss., on October 19, 20 and 21. The total registration was 140, and 158 persons attended the banquet on the second night of the meeting.

The first morning was devoted to registration and provided time for informal conversation and exchange of greetings. Registration for the 42 ladies attending was held on the mezzanine. The meeting was called to order by Baxter F. Wade, Chairman, who presided during the first day, and responded to the welcome offered by Mayor Allen C. Thompson.

The technical session opened with an interesting and entertaining talk by Tip H. Allen, Canton, Miss., Municipal Utilities, on "The Trials and Tribulations of a Small Town Water Works Operator." Discussion of this topic was led by E. M. Stickney, Mobile, Alabama. This paper was followed by a field inspection trip through the Jackson Water Works Plant.

The Manufacturers Association and manufacturers' representatives attending the meeting were hosts that night at a cocktail party and buffet supper in the Victory Foyer of the Hotel.

The second morning of the meeting opened with George H. Godwin, Vice-Chairman, presiding. Arthur N. Beck of the Alabama State Board

(Continued on page 60)

AMONG WATER WORKS MEN...

The ELLIS PIPE CUTTER is *BEST*

FOR CUTTING LARGE SIZES OF PIPE

No. 01 Cuts Pipe 4" to 8"

No. 1 Cuts Pipe 4" to 12'

IMMEDIATE DELIVERY NOW ON ELLIS PIPE CUTTERS

Write for circular and price list

ELLIS & FORD MFG. CO.
FERNDALE 20, MICH.

PROOF OF "STERELATOR EFFICIENCY"

NO JOB TOO LARGE

SEND US COPY OF SPECIFICATIONS

Actual Users—THE BEST PROOF OF ALL—Prove our claims that Everson SterElators are DEPENDABLE - SAFE - EFFICIENT. Easy to operate at LOW MAINTENANCE COST.

Everson SterElators METER-MIX-FEED Chlorine accurately for all water sterelising requirements. Furnished for manual or automatic operation.

Everson SterElators utilize a high vacuum. The indicating FLOW METERS have a 10 to 1 ratio.

SterElators by Everson

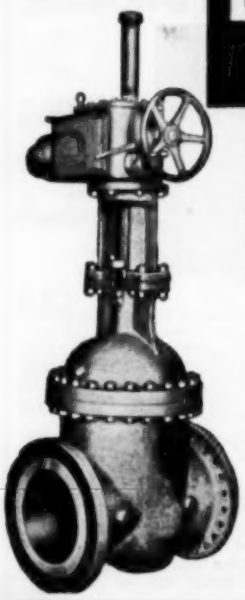
EVERSON MANUFACTURING CORPORATION
221 West Huron Street, Chicago 10, Illinois

(*Continued from page 58*)

of Health gave an interesting talk on "The Relationship Between the State Board of Health and Public Water Supplies," and there followed a discussion led by H. A. Kroeze, director, Mississippi Division of Sanitary Engineering, and W. E. Hooper, Sheffield, Ala. C. W. White of the Alabama State Board of Health gave a timely paper on "Filtration Plant Problems and Chemical Removal of Manganese Deposits From Filters," and the discussion from the floor was led by Clarence D. Lamon, and William O. Mullins.

The afternoon session with Arthur N. Beck, Past-Chairman, presiding, opened with an interesting paper by A.W.W.A. Vice-President W. Victor Weir on the important topic of "Distribution System Operation and Maintenance." There followed a discussion from the floor led by Clifton C. Williams of the Mobile Water Works and Marion G. Stewart of the Natchez, Miss., Water Works. The next feature of this afternoon session was a paper on "Selection and Maintenance of Water Meters" by Jens I. Duus, Rockwell Manufacturing Co., and discussion of this paper was led by Elmer L. Myers, Jackson, Miss., Water Works and R. M. Striger of Feemster and Striger, Tupelo, Miss.

(*Continued on page 62*)



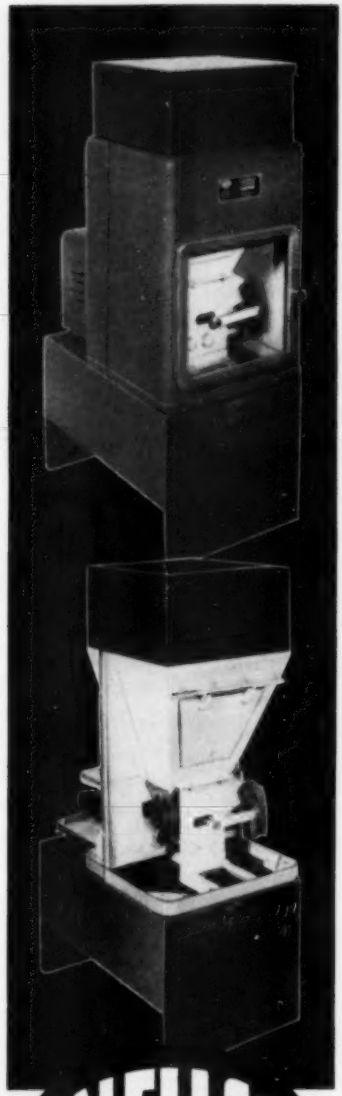
LIMITORQUE
VALVE CONTROLS

Operate by the "push of a button", from either remote or nearby control panel. They prevent damage to stem, seat, disc, gate or plug, because the Torque Seating Switch limits the torque and thereby shuts off the motor, before trouble can occur. Thousands are in daily use on land and sea. Other features are:

Self-contained unit—no gears, nuts or bearings to buy.
Weatherproof, dust-tight and watertight construction.
Hammerblow device.
Non-rotating handwheel built into the unit.
Automatic declutching.
One terminal board for all electrical connections.

Write for new Catalog, and please use your *Business Letterhead* when writing

PHILADELPHIA GEAR WORKS, Inc.
ERIE AVENUE and G STREET, PHILADELPHIA 34, PA.
NEW YORK • PITTSBURGH • CHICAGO • HOUSTON
In Canada: William and J. G. Greey Limited, Toronto



How

TO FEED DRY CHEMICALS FOR WASTE TREATING AND WATER CONDITIONING

INFILCO'S recent 8-page Bulletin No. 215 gives you valuable up-to-the-minute data on how you can feed dry chemicals with greater accuracy and efficiency. It contains detailed descriptions, pictures, drawings, charts and tables covering the new Type E Dry Chemical Feeder . . newest development of our research staff. The E is an outstanding achievement made possible by more than a quarter century of experience in the design and manufacture of chemical feeding equipment. Here, at last, is a simple, compact unit capable of feeding many millions of pounds of chemicals with unvarying accuracy and low upkeep cost. Sturdy and dustless in operation, the E is made for either constant or automatic proportional feeding. Get complete information. Write for Bulletin No. 215, NOW! No cost or obligation is involved!

TYPE E FEEDER FOR DRY CHEMICALS

FREE LABORATORY SERVICE . . SEND FOR THIS WATER CONDITIONING ANALYSIS SHEET!

Get our Water Analysis Sheet, then fill in and return it with a sample. You will receive our laboratory analysis and report promptly. A valuable INFILCO CHEMICAL CALCULATOR slide rule sent FREE to all who return it. There's no cost or obligation.

INFILCO

* BETTER WATER CONDITIONING AND WASTE TREATMENT SINCE 1894 *

INFILCO INC.

SALES OFFICES IN TWENTY SIX PRINCIPAL CITIES

WORLD'S LEADING MANUFACTURERS OF WATER CONDITIONING AND WASTE TREATING EQUIPMENT

(*Continued from page 60*)

The Annual Banquet was held the second night in the Rose Room of the Heidelberg Hotel. Eugene F. Bespalow, Memphis, Tenn., was a superb Master of Ceremonies. W. Victor Weir gave an interesting and entertaining talk on A.W.W.A. affairs, and commented on the fast growth of the Alabama-Mississippi Section.

The final day of the meeting was begun by R. M. King, Layne-Central Co., Memphis, Tenn., who gave a most enlightening paper on "The Installation and Operation of Vertical Turbine Pumps," and a discussion was led by J. H. Pepper. The next highlight on the program was a paper by Sidney J. Mohr Jr., Montgomery, Ala., on the important subject of "Financing Water Works Construction," and discussion was led by William E. Johnson.

A feature of the technical sessions was the spontaneous, instructive and interesting discussions following each paper and address. It is felt that the success of our meeting was due to our excellent speakers and the enthusiastic discussions which followed these papers. Another feature which received favorable comment was the exhibits. Seven of these were well received by the whole group.

In addition to attending the buffet supper and banquet, the ladies were entertained during the meeting by a theater party, a motor trip through the city, visit to antique shops, bridge games, and a luncheon at Le Fleur's.

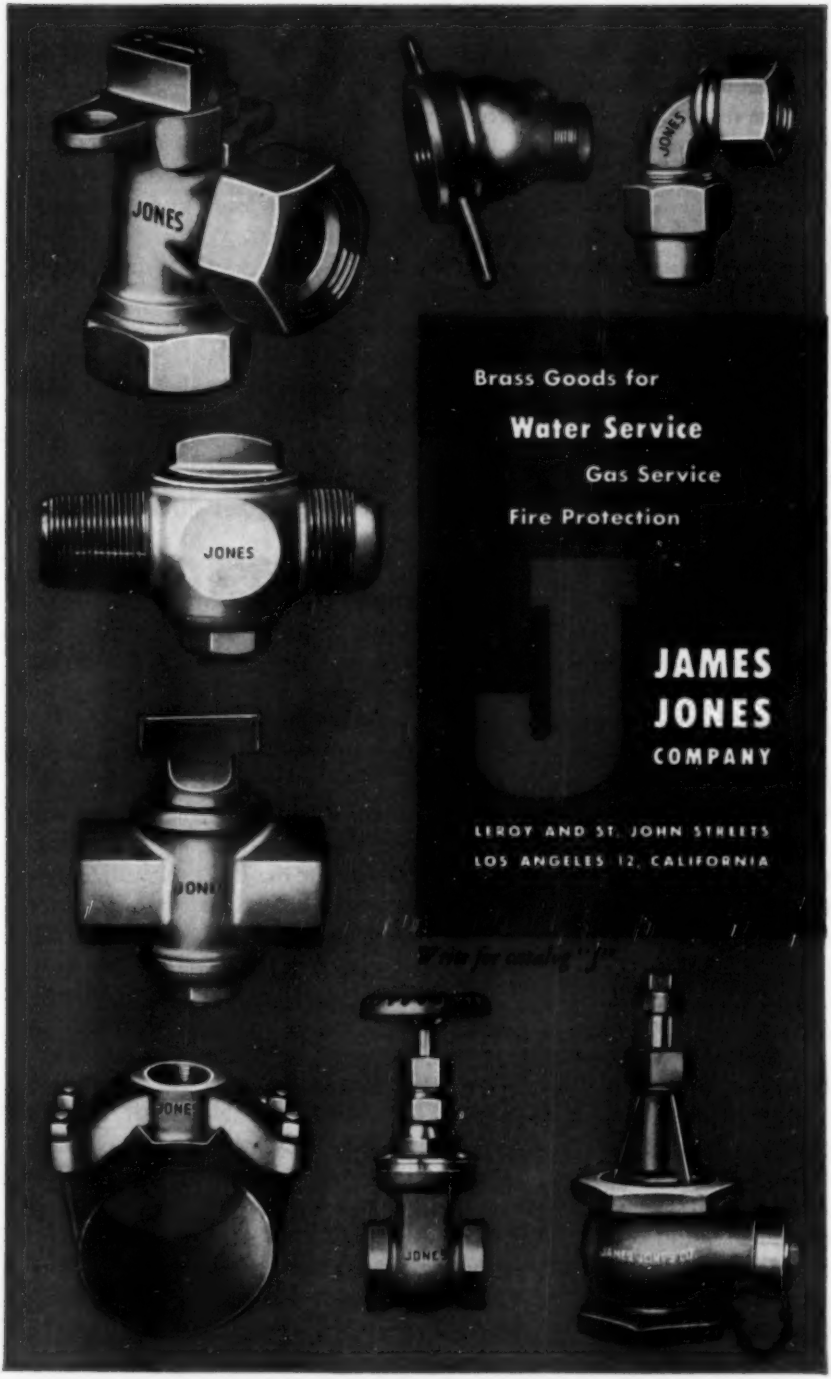
J. L. Snow
Secretary-Treasurer

Virginia Section: The Sixteenth Annual Conference of the Virginia Section, held at Hotel Roanoke, October 24–25, will be remembered by all as a most instructive and entertaining conference. The total of 228 members and guests present exceeded attendance at any previous conference.

On Monday morning an inspection trip through the shops of the Norfolk & Western Railroad was made by a majority present. This railroad company builds all of its steam locomotives and each step of construction was demonstrated on the inspection tour. Other inspection trips arranged were visits to the Salem water treatment plant and to the Carvin's Cove water plant of Roanoke. The Salem plant had been increased in capacity from 1 to 2 mgd. and includes an upflow type of clarifier-softening unit. This plant has only been in operation one month since the additions.

The technical sessions, presided over by Chairman Silcox, were well attended and interest in papers was demonstrated by the discussions following the speakers' presentations. The program was opened by James Carns, engineer from the American Water Works Co., Inc., New York, who spoke on "Aids in Laying Pipe by Mechanical Means." He showed a film illustrating a recent type of excavation mobile unit, which will be on the market within the next few months. This unit has the advantage of going under

(*Continued on page 64*)


JONES
JONES
JONES
JONES
JONES
JONES
Brass Goods for
Water Service
Gas Service
Fire Protection
JAMES
JONES
COMPANY
LEROY AND ST. JOHN STREETS
LOS ANGELES 12, CALIFORNIA
Write for catalog "J"

(*Continued from page 62*)

its own power from job to job and its usefulness for many operations is one of its many attractions.

The final paper of the afternoon was given by L. L. Hedgepeth, technical consultant of the Calco Chemical Div., American Cyanamid Co., Bound Brook, N.J. The technical session resumed on Tuesday morning with the presentation of three motion pictures: "Underground Arteries," "Submersible Deep Well Pump and Motor" and "Air, Water and Industry." Prof. Charles Renn of Johns Hopkins University gave a most interesting lecture and demonstration entitled "Slugs of Bugs."

The final paper on the morning program, entitled "Applying A.W.W.A. Well Standards," was by Paul Schweitzer, president of the Layne-Atlantic Co., Norfolk. The afternoon session resumed with a paper by Kenneth Carl, engineer of the National Board of Fire Underwriters, New York, entitled "Water Supply for Fire Protection in Growing Municipalities." This paper evoked much discussion and debate, particularly on the requirements for small communities. The N.B.F.U. only makes surveys of cities and towns of 25,000 population or greater.

A panel discussion on "Policies of Providing Water Service Beyond Corporate Limits of Towns and Cities" was conducted by C. E. Moore, manager of the Roanoke Water Dept., with X. D. Murden, Portsmouth; H. E. Lordley, Richmond; R. D. Wright, Lynchburg; and R. L. Morrison, Bristol. This panel discussion brought out the most lively expressions from the floor ever heard in a Virginia Section conference.

The annual banquet, always a highlight of the meeting, was held Monday night in the ballroom of the hotel. The group was entertained by Frank Angel, a one-man show, who seemed to have an endless repertoire of tales and jokes. Following the banquet session and the light entertainment, the group adjourned to the Pine Room of the hotel where a bingo party was held. The many ladies present were entertained by a luncheon and card game on Monday.

W. H. SHEWBRIDGE
Secretary-Treasurer

Kentucky-Tennessee Section: The joint meeting of the Kentucky-Tennessee Section and the Kentucky-Tennessee Industrial Wastes and Sewage Works Assn. at Lexington, Ky., October 31–November 2, set a new record for attendance, with a total of 242, including 44 ladies, officially registered for the sessions. The program included two days of technical sessions followed by separate inspection trips for the two associations on the third morning.

A joint session of the two groups was held on the opening day, presided over by A.W.W.A. Chairman Lois Sutherland and IW&SWA Chairman Grant S. Bell. After an opening address by Mayor Tom G.

(*Continued on page 66*)

specify

GENERAL CHEMICAL "ALUM"

WATER experts agree—"alum" is the preferred coagulant for the removal of turbidity, color and other impurities in the water . . . *and General Chemical Aluminum Sulfate is the preferred "alum."*

SEWAGE experts agree—"alum" is preferred for the clarification of sewage because it flocs out the suspended solids and colloids . . . *and General Chemical Aluminum Sulfate is the preferred "alum."*

THE REASON: For over 50 years, General Chemical Aluminum Sulfate has been processed to meet the most rigid chemical and physical specifications. Its quality, uniformity and reliability are preferred by most cities the nation over. For your operations, *specify General Chemical "Alum."*

BASIC CHEMICALS

GC

FOR AMERICAN INDUSTRY

GENERAL CHEMICAL DIVISION

ALLIED CHEMICAL & DYE CORPORATION

40 Rector Street, New York 6, N. Y.

Offices: Albany • Atlanta • Baltimore • Birmingham • Boston • Bridgeport Buffalo • Charlotte • Chicago • Cleveland • Denver • Detroit • Houston Kansas City • Los Angeles • Minneapolis • New York • Philadelphia Pittsburgh • Portland (Ore.) • Providence • San Francisco • Seattle St. Louis • Wenatchee and Yakima (Wash.)

In Wisconsin: General Chemical Company, Inc., Milwaukee, Wis.

In Canada: The Nichols Chemical Company, Limited • Montreal • Toronto • Vancouver

(Continued from page 64)

Mooney of Lexington and a response by G. R. Kavanah, A.W.W.A. Past Chairman, a paper entitled "What the A.W.W.A. Can Do for Operators and Superintendents of Small Systems" was presented by A.W.W.A. Vice-President W. Victor Weir. W. H. Wisely, F.S.W.A. Executive Secretary, related the "Experiences of a Sewage Plant Operator in Public Relations."

The afternoon session opened with a paper on "Investigations on Radioactive Waste Disposal in Relation to Water and Sewage Treatment," prepared by O. R. Placak and Roy J. Morton of the Oak Ridge National Lab., Oak Ridge, Tenn. The session was concluded by a panel discussion on "Financing Water and Sewerage Improvements." W. Howard Hopkin discussed the "Financier's Standpoint"; "What to Expect From Your Consulting Engineer" was presented by L. H. Clouser; and the "Municipal Viewpoint" was presented by L. S. Vance for Kentucky and Arthur L. Dow for Tennessee.

E. E. Jacobson presided over the Tuesday morning session of the A.W.W.A. section which was opened by a discussion of the "Occurrence of Ground Water in Kentucky and Tennessee" by geologists from both states. A panel discussion on "Changes in Water Rate Structures to Keep Pace With Increasing Production Costs" was held, and R. W. Williamson charted the current trends in production costs for small plants while Charles L. Crangle presented data showing recent changes in water rates and needs for further rate adjustments. M. L. West concluded with some sound advice on computing adequate rate structures. The morning session was concluded with a paper by R. T. Hosmon on the "Effect of Consumer Meters on Consumption and Revenue."

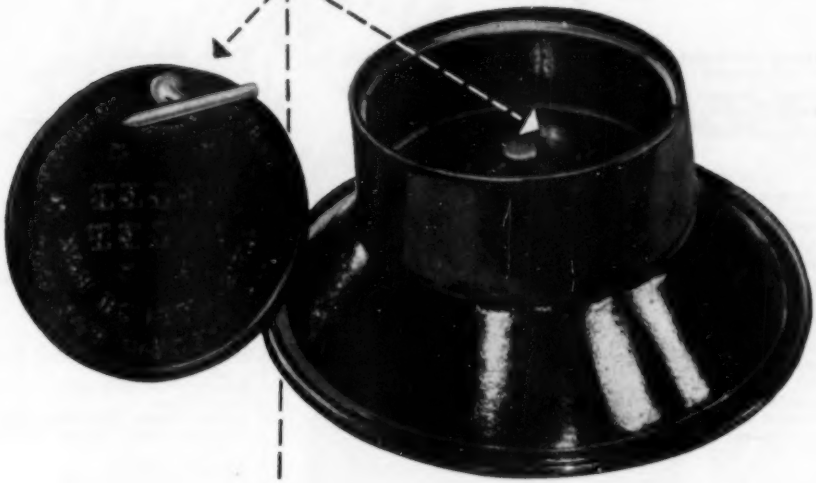
The afternoon session, H. N. Jernigan presiding, began with a paper on "Cathodic Protection of Tanks," prepared by Martin S. Roberts Jr., who outlined the theory and various types of cathodic protection devices and certain variables to be considered in the design of installations. Elwood Farra's paper on "Leak Surveys and Detection" was concerned with checks and controls which can be utilized by the small as well as large water systems. The Board of Experts successfully handled numerous questions on "Operating Problems of Small Plants and Systems." The questions covered practically the entire field of water works practice and dealt with such varied topics as filter media and termites in remote control cables.

On Wednesday morning the Section visited the Lexington water plant and the tour was concluded by a buffet luncheon.

The ladies entertainment committee, headed by Mrs. J. K. Latham, conducted a tour of Central Kentucky Horse Farms and a bridge luncheon to provide recreation for the large number of wives in attendance. General entertainment included a cocktail hour on Monday night and a dinner dance at the Lexington Country Club Tuesday evening.

R. P. FARRELL
Secretary-Treasurer

WABASH DOUBLE-LID COVERS



for MAXIMUM PROTECTION from frost

WRITE FOR CATALOG

The new No. 50 Ford Catalog contains full information. FREE. Send today.

The Wabash Cover was designed to provide the utmost in frost protection for pit water meters. Two lids, with a 4" dead air space between, add extra insulation. Notice also, the extra depth and the sloping skirt that help hold heat loss to a minimum.

Top lid is inset and locked with the patented Ford Lifter Worm Lock. There is no finer meter setting protection.

FOR BETTER WATER SERVICES **FORD**

Manufactured by THE FORD METER BOX COMPANY, INC.

Wabash, Indiana

Index of Advertisers' Products

Acidizing of Water Wells:
Dowell Incorporated

Activated Carbon:
Industrial Chemical Sales Div.

Aerators (Air Diffusers):
Infilco, Inc.
Permutit Co.
Walker Process Equipment, Inc.

Air Compressors:
DeLaval Steam Turbine Co.
Worthington Pump & Mach. Corp.

Air-Lift Pumping Systems:
Worthington Pump & Mach. Corp.

Alum (Sulfate of Alumina):
American Cyanamid Co., Industrial Chemicals Div.
General Chemical Div.
Stuart Corp.

Ammonia, Anhydrous:
General Chemical Div.

Ammonia Receivers:
Worthington Pump & Mach. Corp.

Ammoniators:
Everson Mfg. Corp.
Proportioneers, Inc.
Wallace & Tiernan Co., Inc.

Brass Goods:
American Brass Co.
M. Greenberg's Sons
Hays Mfg. Co.
James Jones Co.
Mueller Co.
A. P. Smith Mfg. Co.

Carbon Dioxide Generators:
Infilco, Inc.
Walker Process Equipment, Inc.

Cathodic Protection:
Dowell Incorporated (magnesium anodes)
Electro Rust-Proofing Corp.

Cement Mortar Lining:
Centriline Corp.
Warren Foundry & Pipe Corp.

Chemical Cleaning of Water Mains:
Dowell Incorporated

Chemical Feed Apparatus:
Belco Industrial Equipment Div., Inc.
Builders-Providence, Inc.
Everson Mfg. Corp.
Infilco, Inc.
Omega Machine Co. (Div., Builders Iron Fdry.)
Permutit Co.
Proportioneers, Inc.
Ross Valve Mfg. Co.
Simplex Valve & Meter Co.
Wallace & Tiernan Co., Inc.

Chemical Scale Removal Services:
Dowell Incorporated

Chemists and Engineers:
(See Prof. Services, pp. 24–27)

Chlorination Equipment:
Everson Mfg. Corp.
Proportioneers, Inc.
Wallace & Tiernan Co., Inc.

Chlorine Comparators:
Hellige, Inc.
Klett Mfg. Co.
LaMotte Chemical Products Co.
Proportioneers, Inc.
Wallace & Tiernan Co., Inc.

Chlorine, Liquid:
Solvay Sales Div.
Wallace & Tiernan Co., Inc.

Clamps and Sleeves, Pipe:
James B. Clow & Sons
Dresser Mfg. Div.
M. Greenberg's Sons
James Jones Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Clamps, Bell Joint:
James B. Clow & Sons
Dresser Mfg. Div.

Clamps, Pipe Repair:
James B. Clow & Sons
Dresser Mfg. Div.
Warren Foundry & Pipe Corp.

Clarifiers:
Chain Belt Co.
Dorr Co.
Infilco, Inc.
Permutit Co.
Walker Process Equipment, Inc.

Cleaning Water Mains:
Flexible Underground Pipe Cleaning Co.
National Water Main Cleaning Co.

Cocks, Curb and Corporation:
Hays Mfg. Co.
James Jones Co.
A. P. Smith Mfg. Co.

Compressors, Portable:
Worthington Pump & Mach. Corp.

Condensers:
United States Pipe & Foundry Co.

Contractors, Water Supply:
Layne & Bowler, Inc.

Controllers, Liquid Level, Rate of Flow:
Builders-Providence, Inc.
Infilco, Inc.
Simplex Valve & Meter Co.
R. W. Sparling

Copper Sheets:
American Brass Co.

Copper Sulfate:
General Chemical Div.

Corrosion Control:
Calgon, Inc.

Couplings, Flexible:
DeLaval Steam Turbine Co.
Dresser Mfg. Div.
Fairbanks, Morse & Co.
Philadelphia Gear Works, Inc.

Dechlorinating Agent:
Virginia Smelting Co.

Diaphragms, Pump:
Dorr Co.
Proportioneers, Inc.

Engines, Hydraulic:
Ross Valve Mfg. Co.

Engineers and Chemists:
(See Prof. Services, pp. 24–27)

Feed Water Treatment:
Calgon, Inc.
Hungerford & Terry, Inc.
Infilco, Inc.

Filter Materials:
Anthracite Equipment Corp.
Infilco, Inc.
Northern Gravel Co.

Filters, Incl. Feed Water:
Belco Industrial Equipment Div., Inc.
Dorr Co.
Everson Mfg. Corp.
Infilco, Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Ross Valve Mfg. Co.
Walker Process Equipment, Inc.

Filtration Plant Equipment:
Builders-Providence, Inc.
Chain Belt Co.
Hungerford & Terry, Inc.
Infilco, Inc.
Omega Machine Co. (Div., Builders Iron Fdry.)
Roberts Filter Mfg. Co.
Stuart Corp.
Walker Process Equipment, Inc.
Welsbach Corp., Ozone Processes Div.

Finders, Pipe:
Jos. G. Pollard Co., Inc.

Fish Screens:
Electric Fish Screen Co.

Fittings, Copper Pipe:
Dresser Mfg. Div.
M. Greenberg's Sons
Hays Mfg. Co.
James Jones Co.

Fittings, Tees, Ells, etc.:
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Dresser Mfg. Div.
James Jones Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
United States Pipe & Foundry Co
Warren Foundry & Pipe Corp.
R. D. Wood Co.

Flocculating Equipment:
Chain Belt Co.
Dorr Co.
Infilco, Inc.
Stuart Corp.
Walker Process Equipment, Inc.

Furnaces:
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.

Furnaces, Joint Compound:
Northrop & Co., Inc.

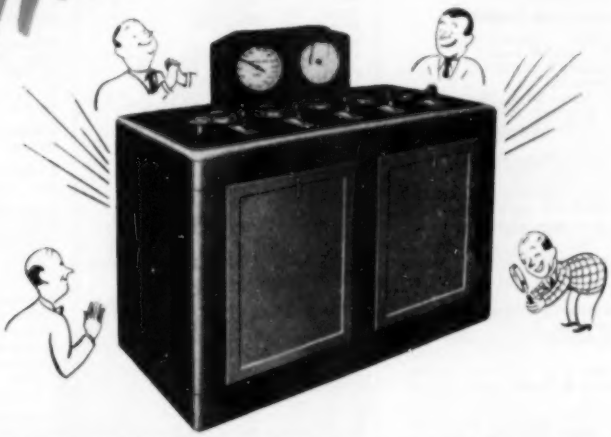
Gages, Liquid Level:
Builders-Providence, Inc.
Infilco, Inc.
Simplex Valve & Meter Co.

Gages, Loss of Head, Rate of Flow, Sand Expansion:
Builders-Providence, Inc.
Infilco, Inc.
Northrop & Co., Inc.
Simplex Valve & Meter Co.
R. W. Sparling

Gasholders:
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Gaskets, Rubber Packing:
Northrop & Co., Inc.

Handsome IS AS *Handsome* DOES!



BUILDERS FILTER OPERATING TABLES are a credit to the modern waterworks. These attractively-styled tables combine complete information on filter operating conditions with positive controls for adjusting the flow rates. As a double assurance of proper adjustments, clearly-labeled valve position indicators are located at each operating handle. For complete information on centralized filter operating equipment that's both attractive and effective, address Builders-Providence, Inc., (Division of Builders Iron Foundry), Providence 1, Rhode Island.

BUILDERS PRODUCTS

The Venturi Meter • Propelofio and Orifice Meters • Kennison Nozzles Venturi Filter Controllers and Gauges • Conveyofio Meters • Type M and Flo-Watch Instruments • Wheeler Filter Bottoms • Master Controllers Chlorinizers — Chlorine Gas Feeders • Filter Operating Tables • Manometers Chronofio Telemeters

BUILDERS PROVIDENCE

Instruments

Gates, Shear and Sluice:
Armco Drainage & Metal Products, Inc.
R. D. Wood Co.

Gears, Speed Reducing:
DeLaval Steam Turbine Co.
Philadelphia Gear Works, Inc.

Glass Standards—Colorimetric Analysis Equipment:
Hellige, Inc.
Klett Mfg. Co.
LaMotte Chemical Products Co.
Photovolt Corp.
Wallace & Tiernan Co., Inc.

Gooseneeks (with or without Corporation Stops):
Hays Mfg. Co.
James Jones Co.
A. P. Smith Mfg. Co.

Greensand; *see* Zeolite

Hydrants:
James B. Clow & Sons
M. Greenberg's Sons
James Jones Co.
Kennedy Valve Mfg. Co.
John C. Kupferle Foundry Co.
Ludlow Valve Mfg. Co.
Mueller Co.
A. P. Smith Mfg. Co.
Rensselaer Valve Co.
Ross Valve Mfg. Co.
R. D. Wood Co.

Hydrogen Ion Equipment:
Hellige, Inc.
LaMotte Chemical Products Co.
Photovolt Corp.
Wallace & Tiernan Co., Inc.

Iron Removal Plants:
American Well Works
Belco Industrial Equipment Div., Inc.
Chain Belt Co.
Hungerford & Terry, Inc.
Infilco, Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Welsbach Corp., Ozone Processes Div.

Jointing Materials:
Atlas Mineral Products Co.
Michael Hayman & Co., Inc.
Hydraulic Development Corp.
Leadite Co., Inc.
Northrop & Co., Inc.

Joints, Mechanical, Pipe:
Carson-Cadillac Co.
Cast Iron Pipe Research Assn.
Central Foundry Co.
James B. Clow & Sons
Dresser Mfg. Div.
United States Pipe & Foundry Co.
Warren Foundry & Pipe Corp.
R. D. Wood Co.

Lime Slakers and Feeders:
Dorr Co.
Infilco, Inc.
Omega Machine Co. (Div., Builders Iron Fdry.)

Magnesium Anodes (Corrosion Control):
Dowell Incorporated

Manometers, Rate of Flow:
Builders-Providence, Inc.

Meter Boxes:
Art Concrete Works
Ford Meter Box Co.
Pittsburgh Equitable Meter Div.

Meter Couplings and Yokes:
Badger Meter Mfg. Co.
Dresser Mfg. Div.
Ford Meter Box Co.
Hays Mfg. Co.
Hersey Mfg. Co.
James Jones Co.
Mueller Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
A. P. Smith Mfg. Co.
Worthington-Gamon Meter Co.

Meter Reading and Record Books:
Badger Meter Mfg. Co.
Buffalo Meter Co.

Meter Testers:
Badger Meter Mfg. Co.
Ford Meter Box Co.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.

Meters, Domestic:
Badger Meter Mfg. Co.
Buffalo Meter Co.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
A. P. Smith Mfg. Co.
Well Machinery & Supply Co.
Worthington-Gamon Meter Co.

Meters, Filtration Plant, Pumping Station, Transmission Line:
Builders-Providence, Inc.
Infilco, Inc.
Simplex Valve & Meter Co.
R. W. Sparling

Meters, Industrial, Commercial:
Badger Meter Mfg. Co.
Buffalo Meter Co.
Builders-Providence, Inc.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Simplex Valve & Meter Co.
A. P. Smith Mfg. Co.
R. W. Sparling
Well Machinery & Supply Co.
Worthington-Gamon Meter Co.

Mixing Equipment:
Belco Industrial Equipment Div., Inc.
Chain Belt Co.
Infilco, Inc.
Walker Process Equipment, Inc.

Ozonation Equipment:
Welsbach Corp., Ozone Processes Div.

Pipe, Asbestos-Cement:
Johns-Manville Corp.
Keasbey & Mattison Co.

Pipe, Brass:
American Brass Co.

Pipe, Cast Iron (and Fittings):
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
Central Foundry Co.
James B. Clow & Sons
United States Pipe & Foundry Co.
Warren Foundry & Pipe Corp.
R. D. Wood Co.

Pipe, Cement Lined:
Cast Iron Pipe Research Assn.
Central Foundry Co.
James B. Clow & Sons
Preload Companies, The
United States Pipe & Foundry Co.
Warren Foundry & Pipe Corp.
R. D. Wood Co.

Pipe Coatings and Linings:
The Barrett Div.
Cast Iron Pipe Research Assn.
Centrilline Corp.
Koppers Co., Inc.
Preload Companies, The
Reilly Tar & Chemical Co.
Warren Foundry & Pipe Corp.

Pipe, Concrete:
American Pipe & Construction Co.
Lock Joint Pipe Co.

Pipe, Copper:
American Brass Co.

Pipe Cutting Machines:
Ellis & Ford Mfg. Co.
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.

Pipe Jointing Materials:
(See Jointing Materials)

Pipe, Steel:
Armco Drainage & Metal Products, Inc.
Bethlehem Steel Co.

Plugs, Removable:
James B. Clow & Sons
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.
Warren Foundry & Pipe Corp.

Potentiometers:
Hellige, Inc.

Pressure Regulators:
Ross Valve Mfg. Co.

Pumps, Boiler Feed:
DeLaval Steam Turbine Co.
Fairbanks, Morse & Co.
Peerless Pump Div., Food Machinery Corp.

Pumps, Centrifugal:
American Well Works
DeLaval Steam Turbine Co.
Economy Pumps, Inc.
Fairbanks, Morse & Co.
Peerless Pump Div., Food Machinery Corp.

Pumps, Chemical Feed:
Infilco, Inc.
Proportioneers, Inc.
Wallace & Tiernan Co., Inc.

Pumps, Deep Well:
American Well Works
Fairbanks, Morse & Co.
Layne & Bowler, Inc.
Peerless Pump Div., Food Machinery Corp.
Worthington Pump & Mach. Corp.

Pumps, Diaphragm:
Dorr Co.
Proportioneers, Inc.

Pumps, Hydrant:
Jos. G. Pollard Co., Inc.

Pumps, Hydraulic Booster:
Fairbanks, Morse & Co.
Ross Valve Mfg. Co.

Pumps, Sewage:
DeLaval Steam Turbine Co.
Economy Pumps, Inc.
Fairbanks, Morse & Co.
Peerless Pump Div., Food Machinery Corp.

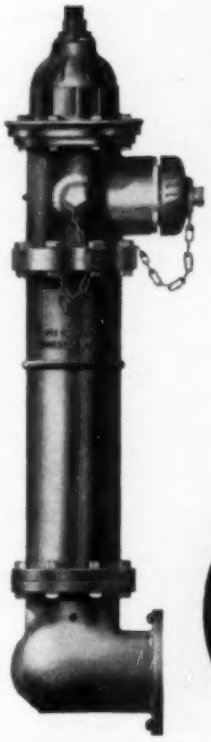
Pumps, Sump:
DeLaval Steam Turbine Co.
Economy Pumps, Inc.
Fairbanks, Morse & Co.
Peerless Pump Div., Food Machinery Corp.

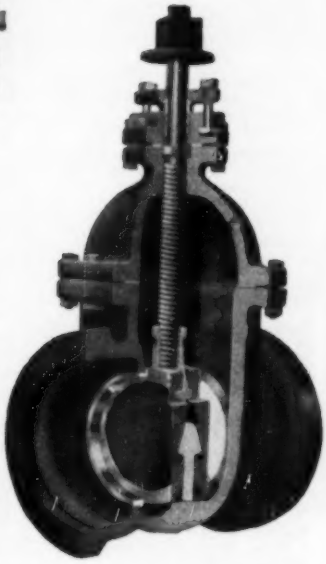
Pumps, Turbine:
DeLaval Steam Turbine Co.
Fairbanks, Morse & Co.
Layne & Bowler, Inc.
Peerless Pump Div., Food Machinery Corp.
Worthington Pump & Mach. Corp.

for BETTER SERVICE *use* M & H

Hydrants, Valves

and pipe line accessories





Hub Ends, Mechanical Joint, Flanged or Screwed.

●

M & H Products Include—

FIRE HYDRANTS
GATE VALVES
TAPPING VALVES
WALL CASTINGS
SPECIAL CASTINGS
TAPPING SLEEVES
CHECK VALVES
FLOOR STANDS
EXTENSION STEMS
SHEAR GATES
MUD VALVES
VALVE BOXES
FLAP VALVES
SLUDGE SHOES
FLANGE AND FLARE FITTINGS
FLANGED FITTINGS
B & S FITTINGS
CUTTING-IN TEES

VALVES: A.W.W.A. type, iron body, bronze mounted with double disc parallel seat or solid wedge type. Non-rising stem, outside screw and yoke, or with sliding stem and lever. Also furnished hydraulically operated. Square bottom type operates in any position. All rugged and dependable, made of best material with highest quality workmanship.

HYDRANTS: Standard A.W.W.A. type approved by Underwriters and Factory Mutuals. Dry top, revolving head, easy to lubricate. High efficiency because barrel diameter not reduced and there are no working parts or obstructions in waterway.

FOR WATER WORKS AND SEWERAGE WORKS MATERIALS, WRITE FOR CATALOG NO. 32.

FOR FIRE PROTECTION MATERIALS, WRITE FOR CATALOG NO. 40.

M & H VALVE
AND FITTINGS COMPANY
ANNISTON, ALABAMA

Recorders, Gas Density CO_2, NH_3, SO_2, etc.:
Permutit Co.
Wallace & Tiernan Co., Inc.

Recording Instruments:
Builders-Providence, Inc.
Infilco, Inc.
R. W. Sparling
Wallace & Tiernan Co., Inc.

Reservoirs, Steel:
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Sand Expansion Gages:
(See Gages)

Sleeves:
(See Clamps)

Sleeves and Valves, Tapping:
James B. Clow & Sons
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Sludge Blanket Equipment:
Permutit Co.

Soda Ash:
Solvay Sales Div.

Sodium Hexametaphosphate:
Calgon, Inc.

Softeners:
Belco Industrial Equipment Div., Inc.
Dorr Co.
Hungerford & Terry, Inc.
Infilco, Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.

Softening Chemicals and Compounds:
Calgon, Inc.
Infilco, Inc.
Permutit Co.

Standpipes, Steel:
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Steel Plate Construction:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Storage Tanks:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Strainers, Suction:
M. Greenberg's Sons
R. D. Wood Co.

Sulfur Dioxide, Liquid:
Virginia Smelting Co.

Surface Wash Equipment:
Permutit Co.
Stuart Corp.

Swimming Pool Sterilization:
Belco Industrial Equipment Div., Inc.
Everson Mfg. Corp.
Omega Machine Co. (Div., Builders Iron Fdry.)
Proportioneers, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.

Tanks, Steel:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Tapping Machines:
Hays Mfg. Co.
Mueller Co.
A. P. Smith Mfg. Co.

Taste and Odor Removal:
Industrial Chemical Sales Div.
Infilco, Inc.
Proportioneers, Inc.
Walker Process Equipment, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.

Telemeters, Level, Pump Control, Rate of Flow, Gate Position, etc.:
Builders-Providence, Inc.

Turbidimetric Apparatus (For Turbidity and Sulfate Determinations):
Hellige, Inc.
Wallace & Tiernan Co., Inc.

Turbines, Steam:
DeLaval Steam Turbine Co.

Turbines, Water:
DeLaval Steam Turbine Co.

Valve Boxes:
Central Foundry Co.
James B. Clow & Sons
Ford Meter Box Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valve Inserting Machines:
A. P. Smith Mfg. Co.

Valves, Altitude:
Ross Valve Mfg. Co., Inc.

Valves, Butterfly, Check, Flap, Foot, Hose, Mud and Plug:
James B. Clow & Sons
M. Greenberg's Sons
Rensselaer Valve Co.
R. D. Wood Co.

Valves, Detector Check:
Hersey Mfg. Co.

Valves, Electrically Operated:
James B. Clow & Sons
Kennedy Valve Mfg. Co.
Philadelphia Gear Works, Inc.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Valves, Float:
Ross Valve Mfg. Co., Inc.

Valves, Gate:
Dresser Mfg. Div.
James Jones Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Hydraulically Operated:
James B. Clow & Sons
Kennedy Valve Mfg. Co.
Philadelphia Gear Works, Inc.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Large Diameter:
James B. Clow & Sons
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Regulating:
Ross Valve Mfg. Co.

Valves, Swing Check:
James B. Clow & Sons
M. Greenberg's Sons
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Waterproofing
Inertol Co., Inc.

Water Softening Plants:
(See Softeners)

Water Supply Contractors:
Layne & Bowler, Inc.

Water Testing Apparatus:
Hellige, Inc.
LaMotte Chemical Products Co.
Photovolt Corp.
Wallace & Tiernan Co., Inc.

Water Treatment Plants:
American Well Works
Chain Belt Co.
Chicago Bridge & Iron Co.
Dorr Co.
Everson Mfg. Corp.
Hungerford & Terry, Inc.
Infilco, Inc.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Stuart Corp.
Walker Process Equipment, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.

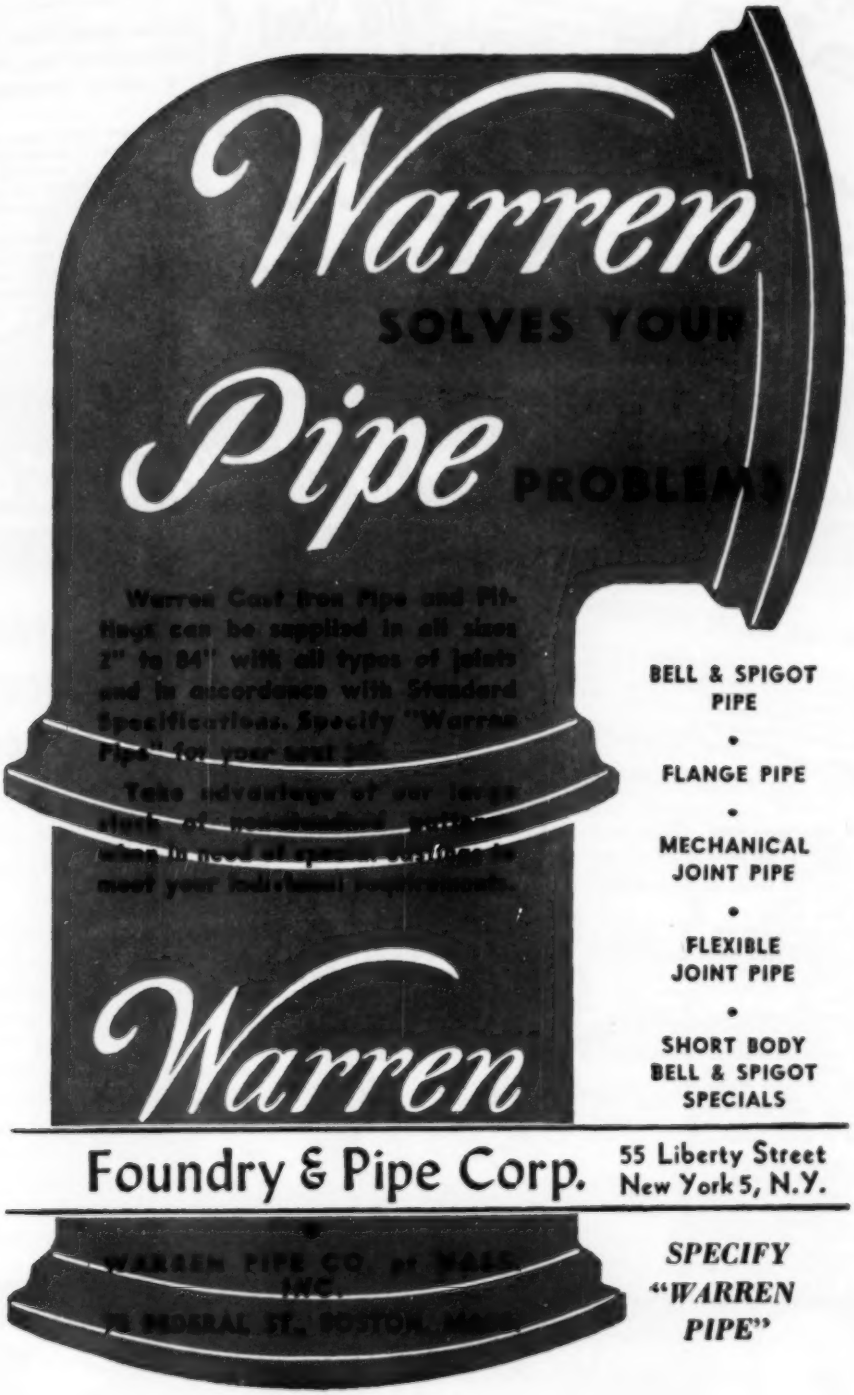
Well Acidizing:
Dowell Incorporated

Well Drilling Contractors:
Layne & Bowler, Inc.

Wrenches, Ratchet:
Dresser Mfg. Div.

Zeolite:
Hungerford & Terry, Inc.
Infilco, Inc.
Permutit Co.
Roberts Filter Mfg. Co.

A complete Buyers' Guide to all water works products and services offered by A.W.W.A. Associate Members appears in the 1948 Membership Directory.


Warren
SOLVES YOUR
Pipe PROBLEMS
Warren Cast Iron Pipe and Fittings can be supplied in all sizes 2" to 84" with all types of joints and in accordance with Standard Specifications. Specify "Warren Pipe" for your next job.
Take advantage of our large stock of standard pipe ... items in need of special ... to meet your individual requirements.
Warren
BELL & SPIGOT PIPE
•
FLANGE PIPE
•
MECHANICAL JOINT PIPE
•
FLEXIBLE JOINT PIPE
•
SHORT BODY BELL & SPIGOT SPECIALS
Foundry & Pipe Corp.
55 Liberty Street
New York 5, N.Y.
WARREN PIPE CO. of MASS. INC.
SPECIFY "WARREN PIPE"

Bill to Require Water Meters in All Homes
Maps Plan to End Long Spigot Binge, Avert Crises
EVEN WATER IS SHORT
IN RECENT YEARS, there has been considerable speculation, along with some presumably accurate estimates, about the depletion of various national resources. Little or nothing has been done, however, about a possible shortage of water. Demand for water has increased 150 fold to have increased 150 fold in the last 15 years, on a na
Water Short In Many Parts Of Nation
Basic Supply Down In Western Sections
The nation's most precious resource, water, is running short in many sections, a survey showed today.
In a few cases, such as at New York, the water shortage is a temporary matter, caused by a lack of rainfall.
DEMAND FOR WATER FETTERS ECONOMY
National Survey Shows High and Unplanned Rises, With a Lopsided Distribution
The United States faces heavy economic losses in the foreseeable future because of unplanned, excessive increases in the use of its most precious mineral resource—water.
In recent years, overdevelopment of ground water resources by industry, more widespread use of air conditioning, overdevelopment for irrigation, fostered by high

"You never miss water 'til the well runs dry"

RATIONS WATER IN DROUGHT

AIN, which has been affecting the water supplies of several rn seaboard states, hits the town of Roosevelt, N. J., where the rells have gone dry. Here, a number of residents form a "bucket ting to get their share of water transported by two fire trucks city of Highstown, which is ten miles away.

CITY IS OUTGROWING YIEL

The Health Department today informed the World-Telegram that the average person in this city—and that includes adults and little children, too—uses 110 gallons of water a day in the home.

Don't Have to Pay.

It is doubtful, authorities said, that New Yorkers are any cleaner than residents of other cities. They are just profligate of water because they don't have to pay for it officials agree.

Where domestic users have metered water service everyone is more careful since every extra gallon means money out of pocket.

There are some homes in this city and many more just outside where each house has an individual meter. In these areas the average per capita consumption of water is from 50 to 75 gallons a day.

A survey of consumption in districts served by the Jamaica Water Supply Co. and the New York Water Service Corp. of Woodhaven, both in Queens, revealed that householders don't waste water when they are paying for it themselves. The same fact was borne out in Lynbrook, L. I., a

ation by
ng-Term Ba
ently Needu
er consumi
e "norma
000,000 gal
otential re
eeks. Nev
ve only

Start Metering Now!

When there have been water shortages in past years, New York City has played around with some system to meter water used in residences. Then when plenty of rain or snow came, the whole thing was dropped until the next drought reminded officials again that metering might be a good idea.

As a result of this backing and filling, the city has made it easy for a careless public to waste some 200,000,000 gallons of water every day. Now, that waste has got us into a critical water shortage.

Even though there is only enough water in the reservoirs to last 60 days, New Yorkers go on being among the worst water wasters in the country. They flush toilets for a match or a cigaret butt. They wash dishes under an open tap. They find scores of ways to fritter away what's left of the supply. For the most part they seem indifferent to the danger threatening their own precious water.

Metering would provide the only way we see to bring that danger home to the public. With meters, people who waste water pay for it.

In New York suburban areas where water is metered, each person uses from 50-75 gallons daily. But in the city, where the supply is free, the average is 110 gallons every day.

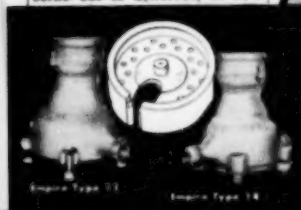
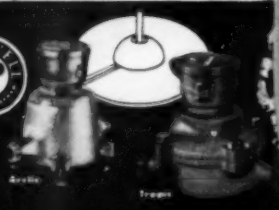
One startling fact about the huge consumption is that at least a quarter of the water is wasted. About [illegible] is lost before it ever gets to consumers—by leakage from the city's underground mains and pipes. Beyond that, the city estimates that about 20% of the water that does get to users is wasted due to leaky faucets and similar carelessness.

• **Metering**—Officials of the Dept. of Water Supply, Gas & Electricity think [illegible] of water would stop a lot of [illegible] but thus prevent such [illegible] metering

CAN YOU AFFORD TO BE WITHOUT METER CONTROL?

The serious water shortage in New York City has dramatized the fact that water supply levels are receding nationwide.

Many municipalities have lost or are losing an adequate supply of water through needless waste. Extravagant usage only occurs where the water system is not fully metered. If your system is one of these, don't wait until it's too late. We've prepared a complete program that will help you present the true facts on the advantages of 100 per cent metering to your customers and municipal authorities. Write today—no obligation involved.


Pittsburgh Equitable Meter Division
ROCKWELL MANUFACTURING CO.
PITTSBURGH 8, PA.
Atlanta Boston Chicago Columbus Houston
Kansas City Los Angeles New York
Pittsburgh San Francisco Seattle Tulsa


"Hey, Joe! Did you ever see a $100 bolt?"

JOE: "What d'ya mean, a hundred-dollar bolt?"

GUS: "Just what I said. We're raising Number 3 Gate just now and this anchor bolt let go."

JOE: "But we put that gate in less than two years ago, and . . ."

GUS: "Yeah, I know. But we used ordinary bolts and this one's already rusted through. It'll cost at least a hundred bucks to take that gate out, dig the old bolt out of the concrete and set a new one in."

JOE: "I guess it will. But from here out we don't make that mistake twice. From now on everything that goes in is Everdur."

Most sewage and waterworks engineers have discovered that the most economical way to lick the corrosion problem in their plants is to use Everdur*—ANACONDA's copper-silicon group of alloys. There are plants where equipment made of Everdur has been doing it for over 22 years.

If you don't already know about Everdur, let us tell you about its high strength, durability and how easy it is to fabricate it into lightweight, low-cost wrought assemblies. Just ask for the Everdur booklets. Let our Technical Department counsel you on any special problems or applications. Write to The American Brass Company, Waterbury 20, Connecticut. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario.

49170

Where corrosion resistance counts—use Everdur

ANACONDA

copper-silicon alloys

*Reg. U.S. Pat. Off.

LEADITE

Jointed for . . . Permanence with LEADITE

Generally speaking, most Water Mains are buried beneath the Earth's surface, to be forgotten,—they are to a large extent, laid for permanency. Not only must the pipe itself be dependable and long lived,—but the joints also must be tight, flexible, and long lived,—else leaky joints are apt to cause the great expense of digging up well-paved streets, beautiful parks and estates, etc.

Thus the "jointing material" used for bell and spigot Water Mains MUST BE GOOD,—MUST BE DEPENDABLE,—and that is just why so many Engineers, Water Works Men and Contractors aim to PLAY ABSOLUTELY SAFE, by specifying and using LEADITE.

Time has proven that LEADITE not only makes a tight durable joint,—but that it improves with age.

The pioneer self-caulking material for c. i. pipe.
Tested and used for over 40 years.
Saves at least 75%

THE LEADITE COMPANY
Girard Trust Co. Bldg. Philadelphia, Pa.

No Caulking